Degradation of antibiotics in hospital wastewater via UV-C photoperoxidation

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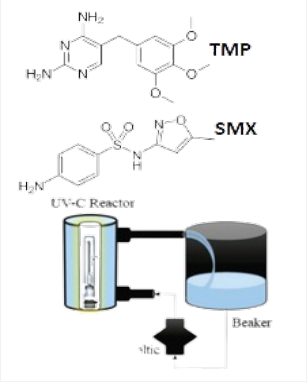

In Brazil, as well as in other countries around the world, it is common to dispose of hospital wastewater in the domestic sewage system to be treated in wastewater treatment plants (WWTPs). However, such disposal may contribute to the spread of antimicrobial resistance. This work sought to apply the UV-C photoperoxidation process to degrade two antibiotics commonly used in Brazilian hospitals: sulfamethoxazole and trimethoprim. 24-hour composite samples were collected from a hospital in Belo Horizonte - Brazil and characterized according to physicochemical parameters. Target compounds were removed by UV-C photoperoxidation (254 nm, pH 6.91, 100 mg L^{-1} of H_2O_2, in 20 minutes) in spiked hospital wastewater sample (100 µg L^{-1}), reaching 83% and 16% removal rates, respectively. In this scenario, the treatment process known as photoperoxidation characterized by its high oxidative capacity, has stood out as an efficient solution.

Introduction

Hospitals consume a large amount of water and generate liquid effluents, which include a variety of substances, such as drugs, metals, bacteria, solvents, among others [1]. In the Brazilian context, it is important to note that healthcare institutions generally do not pre-treat their effluents prior to disposal in the domestic sewage system [1]. This practice hast he potential to compromise the operation of biological reactors operating in conventional wastewater treatment plants (WWTPs), since substances that are toxic to bacteria, such as antibiotics, may accumulate in these reactors. Even at low concentrations (ng to µg L^{-1}) [2], antibiotics may also contribute to the selection of antibiotic resistant bacteria and increased spread of resistance genes.

Sulfamethoxazole (SMX) and trimethoprim (TMP) are two antibiotics that are commonly prescribed simultaneously. This combination results in an efficient bactericidal effect with a broad spectrum of action [3]. It is estimated that approximately 30% and 40% of the consumed dose of SMX and TMP are excreted in the original form, respectively [4]. In addition, SMX has been reported to occur in hospital wastewater (0.9 to 6.5 µg L-1) [5]. SMX is associated with antibiotic resistance in wastewater and has therefore been the subject of extensive reserach [[6]. The reported concentration of TMP in hospital wastewater ranges between 1.4 to 210 µg L^{-1} [5,7].

In this scenario, the aim of this work is to promote the removal of the antibiotics TMP and SMX, present in hospital wastewater, using the UV-C photoperoxidation process.

Material and Methods

Composite hospital wastewater samples were collected over 24 hours (in November 2023) and characterized based on physicochemical parameters [8]. Before performing the degradation assays, the UV-C lamp was preheated for 20 minutes to stabilize the photon emission. Assays were carried out to remove the target compounds (TMP and SMX) by the UV-C photoproxidation process (254 nm, 100 mg L^{-1} H_2O_2, pH 6.9, 20 minutes), in pre-filtered (20 µm) spiked raw hospital wastewater (100 µg L^{-1}).

Results and Discussion

As shown in Figure 1, photoperoxidation was effective in degrading the antibiotics SMX and TMP, achieving a removal percentage of 83% and 16%, respectively. In addition, the peroxidation control containing only H_2O_2 did not result in the degradation of the target compounds (Figure 2), and UV-C radiation alone also did not show significant removal (Figure 3), demonstrating that photoperoxidation (UV-C/H_2O_2) was the process responsible for the degradation of the targets.Other studies have highlighted the efficiency of employing UV-C/H_2O_2 to remove these compounds from water and other matrices [9,10]. SMX degradation of > 99% (C_0 100 µg L^{-1}) was achieved in 90 minutes of treatment by the UV-C/H_2O_2 [9] in urban wastewater samples from secondary treatment. Similar results were reported by [10], who achieved complete SMX removal in 11 minutes and > 90% TMP removal in 100 minutes of treatment by UV-C/H_2O_2 (C_0 100 µg L^{-1}), also in urban wastewater from secondary treatment. It is important to note that, in the studies reported in the literature, the process was used on a wastewater matrix previously treated by secondary treatment, thus characterizing a less complex matrix compared to the matrix investigated in this study, namely raw hospital wastewater.

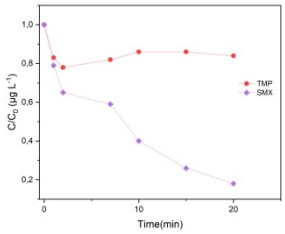

Figure 1. Degradation of target compounds (100 µg L^{-1}) by Photoperoxidation (UV-C/H_2O_2) in hospital wastewater at natural pH, 100 mg L^{-1} of H_2O_2 , in 20 minutes.

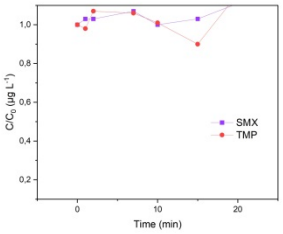

Figure 2. Degradation of target compounds (100 µg L^{-1}) by peroxidation (H_2O_2) in hospital wastewater at natural pH, 100 mg L^{-1} of H_2O_2, in 20 minutes.

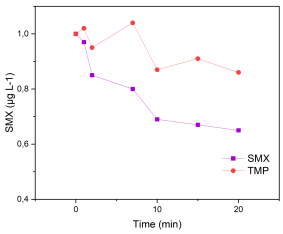

Figure 3. Degradation of target compounds (100 µg L^{-1}) by photolysis (UV-C) in hospital wastewater at natural pH, in 20 minutes.

The main physicochemical parameters of the hospital wastewater are shown in Table 1. The sample is slightly alkaline (pH = 6.91) and low alkalinity (151 mg $CaCO_3$ L^{-1}). The concentrations observed are in accordance with the typical values for Brazilian hospital wastewaters reported in the literature [11-13].

Table 1. Physicochemical properties of the raw hospital wastewater pH from Belo Horizonte - Brazil (November 2023)

Parameter	**Hospital wastewater**
pH	6.91±0.01
Electrical conductivity (µS cm^{-1})	755.2±3.5
Alkalinity (mg $CaCO_3$ L^{-1})	151.5±1.59
Turbidity (NTU)	40.30±2.69
COD (mg O_2 L^{-1})	417.6±19.6
SST (mg L^{-1})	66.30±4.96
SDT (mg L^{-1})	409.67±6.66

Conclusions

The Photoperoxidation (UV-C/H_2O_2) process was proved as an alternative for the treatment of hospital wastewater prior to disposal in the sewage system, reducing the concentration of antibiotics, SMX and TMP.

Acknowledgments

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