Analysis of degradation of the micro pollutant amoxicillin by photolysis and evaluation of the degradation products

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Abstract

Emerging micro pollutants are substances that have recently been identified in environmental matrices, of which information on environmental permanence and toxicity is still scarce. Due to their chemical structure, antibiotics are more stable and require more complex processes for degradation. The present study aimed to elaborate a proposal for the degradation of the β-lactam antibiotic amoxicillin by photolysis, evaluating the formation of by-products. As a methodology, 100 μg /L amoxicillin solutions were submitted to different ultraviolet light bulbs irradiations, at different power and distances, by means of a 100 mL batch quartz reactor. To evaluation degradation of amoxicillin and of the products generated, the high-performance liquid chromatography-mass spectrometry was used. As a result, the best degradation condition (greater than 90% reduction of the original molecule) was with a 95W light bulb, at a distance of 5 cm from the sample at 10 min irradiation time. Two by-products originated under different pH conditions of the irradiated solution were identified. Based on the obtained results, it is concluded that this prototype and the applied method can be used in the future to reduce this pollutant.

Keywords: emerging pollutant, degradation, amoxicilin, water

1. Introduction

Municipal water treatment plants are designed to control a wide range of substances that are efficiently and consistently disposed of, but removal of micro pollutants may not be effective. Micro pollutants are present contaminants of ng/L up to mg/L, defined as potentially toxic substances of which the effects and permanence in the environment are still unknown (Moreıra; Gonçalves; Beretta, 2013).

With the increase in drug consumption, there is consequently the elimination of non-metabolized concentrations in effluents, which has become a new environmental problem. Among these drugs, antibiotics are some of the most worrisome, due to the potential for development of biological resistance (Ahuja, 2009).

In a study by Poudel et al. (2009) on resistance of wastewater bacteria to exposure of some antibiotics, amoxicillin showed up as one of the most prominent drugs. However, amoxicillin is eliminated from the body in a non-metabolized form at levels above 70% (Luo et al., 2014). Therefore, there is a need to develop effective treatment alternatives for the reduction of antibiotic levels in the water supply. In this context, ultraviolet (UV) radiation is a process of treatment that looks promising in the removal of drugs, personal care products and endocrine disrupters (Boreen et al, 2005).

The present study aimed to evaluate the degradation of the amoxicillin antibiotic in water by direct photolysis under different conditions using a batch reactor and analyzing the degradation products originated.

2. Methods

For analysis of drug concentration, amoxicillin (Sigma-Aldrich) standards were made for the calibration curve by high performance liquid chromatography coupled to a mass spectrometer (HPLC-MS). For the degradation tests, solutions of 100 μg/g were inserted in a batch reactor containing ultraviolet light bulbs. The reactor was made of quartz and it is shown in Figure 1.

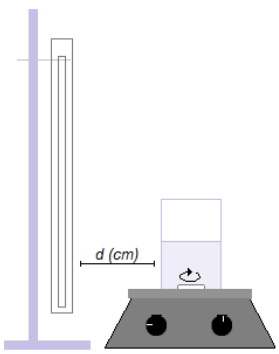

Figure 1. Quartz reactor for amoxicillin degradation

The Philips brand UV-C germicidal light bulbs of 16, 55 and 95 W were tested and were placed at 5, 10 and 15 cm from the container containing the solution to be treated. The pH of the solutions was varied between 3, 7 and 9 as well. All samples were shaken at 110 rpm and collected at 0, 2, 4, 6, 8 and 10 minutes. For the degradation product analyzes, the compounds with m/z 384, 340 and 515 (Nägele and Moritz, 2005) were monitored.

3. Results

There are no differences in the pH results in the samples. Then, it was chosen pH 7 to show in this paper the evaluate the time, kind of light bulb and distance from the samples for amoxicillin degradation. The results are showed in Figures 2, 3 and 4.

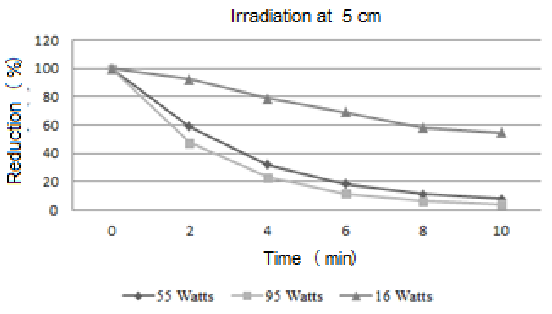

Figure 2. Irradiation of different light bulb at 5 cm of distance.

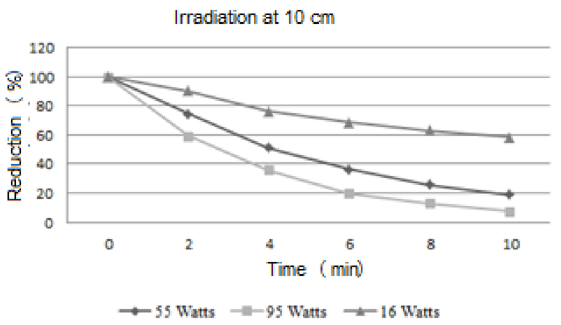

Figure 3. Irradiation of different light bulb at 10 cm of distance.

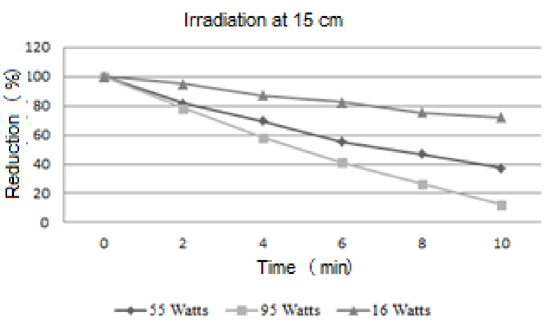

Figure 4. Irradiation of different light bulb at 15 cm of distance.

Using 95W light bulbs achieved the best performance among the three powers tested. The most suitable distance was at 5 cm from the reactor being the reduction of amoxicillin over 90% around 8 min. There was no interference of pH in the results. The byproduct m/z 515 which probably is amoxicillin 4-hydroxyphenylglyl and the by-product m/z 384, known as amoxicillin penicillinic acid, have been identified.

4. Conclusion

Based on the results obtained and the literature consulted, it is concluded that new water treatment techniques, wich include the removal of the emerging contaminants called micro pollutants, should still be studied and carefully evaluated, so that procedures that despite degrading the original substance, resulting in the generation of even more harmful structures for the maintenance of the quality of life by consumers and final receiving bodies are not adopted.

The highlight in the current research is that it was possible 100 µg/g amoxicilin degradation in water using 95 W UV light bulb at a distance of 5 cm of the sample with 90% of efficiency.

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