DEGRADATION OF THE ANTIBIOTIC AMOXICILLIN BY FENTON PROCESSES

Emerging Pollutants and Managing Wastewater and Waste

UNESCO-IWRA ONLINE CONFERENCE
17-19 JANUARY 2023
3rd IN THE IWRA ONLINE CONFERENCE SERIES

INTRODUCTION

Amoxicillin (AMX) is a broad spectrum antibiotic and its mechanism of action is based on the ability to inhibit the synthesis of a peptide responsible for the integrity of the cell wall of prokaryotic cell (ARRUDA; FARO, 2019). It is the most widely used antibiotic worldwide and represents approximately 30% of all oral antibiotic substances consumed in the Americas region (WHO, 2018). The main route of input of contaminants of emerging concern, such as AMX, into water bodies is the release of inefficiently treated effluents or by the contribution through the excretion of metabolized or unchanged substances (GLASSMEYER et al., 2005; ALEXY et al., 2006; KÜMMERER, 2009; MELO et al., 2009; YANG et al., 2017). Advanced oxidative processes (AOPs), such as Fenton, are emerging technologies used in the degradation of organic pollutants with high chemical stability and little biodegradability in effluents and are based on the formation of the hydroxyl radical (•OH) and, associated with its high power of oxidation allows the degradation of various organic pollutants by oxidizing recalcitrant organic compounds into simpler species such as carbon dioxide (CO_2), water and inorganic ions (TIBURTIUS; PERALTA-ZAMORA; LEAL, 2004; BOKARE; CHOI, 2014).

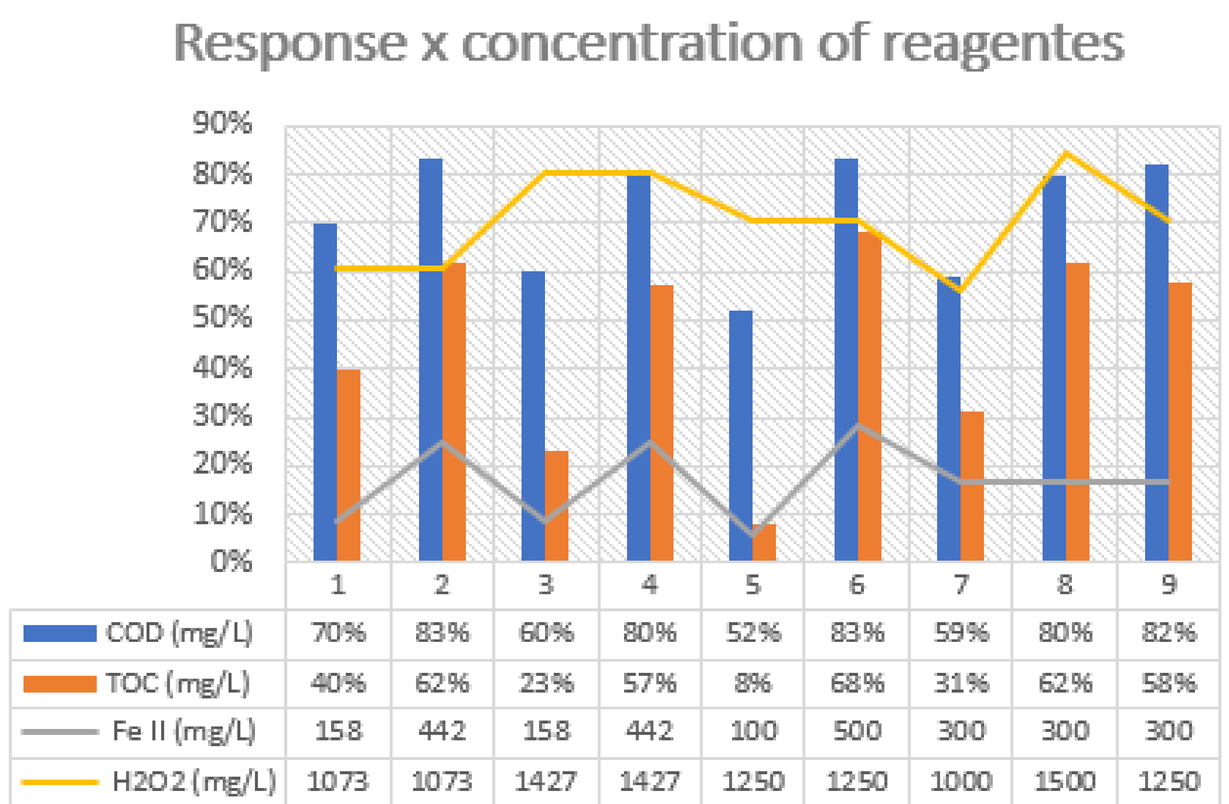
METHODOLOGY

Nine (9) tests were conducted with different levels for the concentration of Fe^{2+} (100 - 500 mg L^{-1}) e H_2O_2 (1000 - 1500 mg L^{-1}). For the tests, 200 mL of the synthetic effluent had pH adjusted to 3.0 with sulfuric acid. Then, ferrous sulfate heptahydrate and hydrogen peroxide were added at the concentrations indicated in the experimental design. The best dosage of reagents was determined considering the highest chemical oxygen demand (COD) and total organic carbon (TOC) removals. The best condition was used for amoxicillin degradation with initial concentration of 200 ug L^{-1} in the synthetic effluent by Fenton and photo-Fenton (irradiated with UV and sunlight).

RESULTS AND DISCUSSION

Figure 1 shows the effects of the reagents on the removal of COD and TOC.

Figure 1 – Response of COD e TOC x concentration of Fe II e H_2O_2

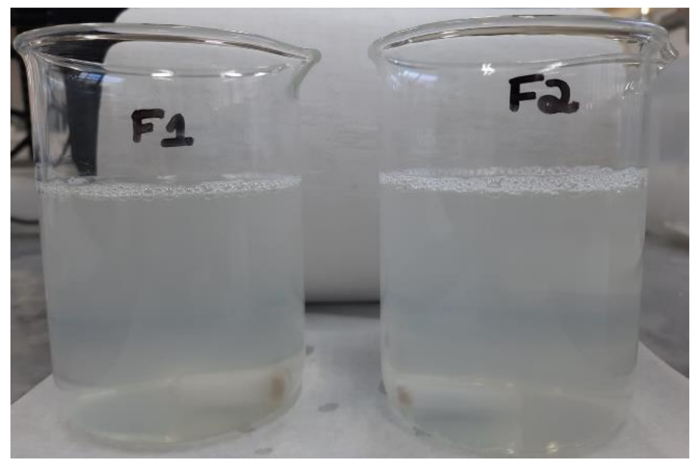


Source: Author (2022)

According to the results obtained, considering the highest removal of the evaluated parameters, it was decided to adopt the following concentration of reagents: 500 mg L^{-1} of Fe^{2+} and 1,250 mg L^{-1} of hydrogen peroxide.

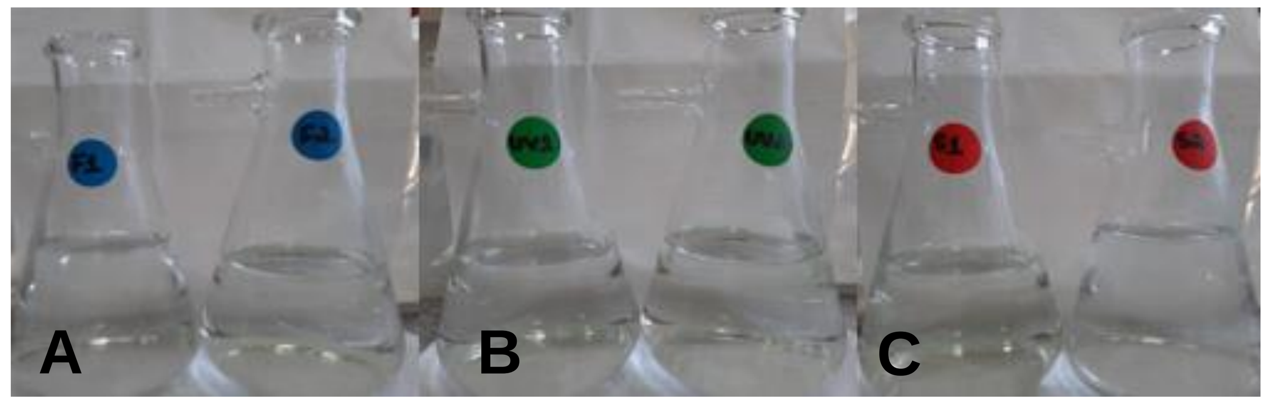
In **figure 2**, the raw effluent is shown and in **figure 3** the effluents treated by Fenton (**3.a**), Fenton-UV (**3.b**) and Fenton-sunlight (**3.c**).

Figure 2 – Synthetic effluent (raw)



Source: Author (2022)

Figure 3 – Treated effluents



Source: Author (2022)

The removal results are presented in **table 1.**

Table 1 – Results obtained between the systems

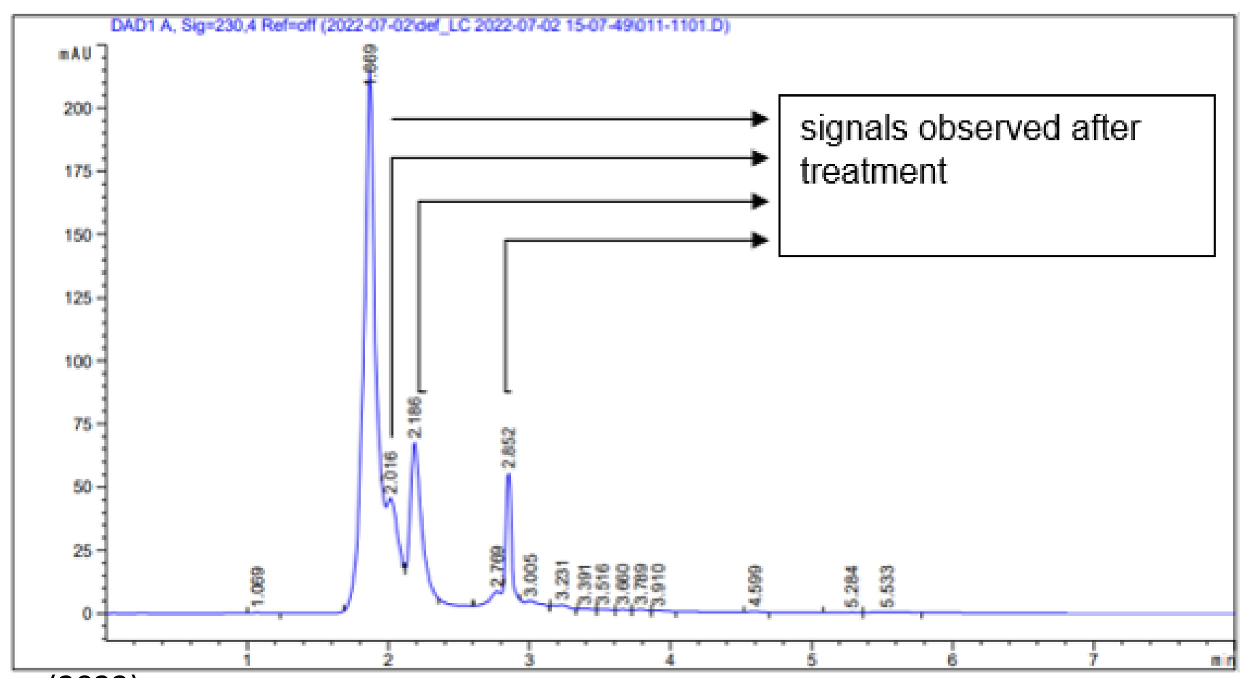
Value	Removal (%)		
	Fenton	Photo-Fenton UV	Photo-Fenton Sunlight
Amoxicillin	<LQ[1]	<LQ[1]	<LQ[1]
Total Organic Carbon	79,7	69,3	79,7
Biochemical Oxygen Demand	81,1	82	82,5
Chemical Oxygen Demand	81,8	79,3	81,1
Total Suspended Solids	100	100	100
Turbidity	99	98,2	98,7

[1] LQ = Limit of quantification (5 ug L^{-1})

Source: Author (2022)

According to the signs observed in the chromatograms of the treated effluents (**figure 4**), four compounds were detected after treatment and may indicate the formation of by-products originating from the incomplete oxidation of precursors in the raw effluent. These compounds were detected in the three proposed treatment processes, however, the areas obtained (**table 2**) suggest that the Fenton process assisted by sunlight may be less efficient in completely degrading the substances in the effluent and contributes to the formation of by-products.

Figure 4 – Signals observed after treatment by High Performance Liquid Cromatography



Source: Author (2022)

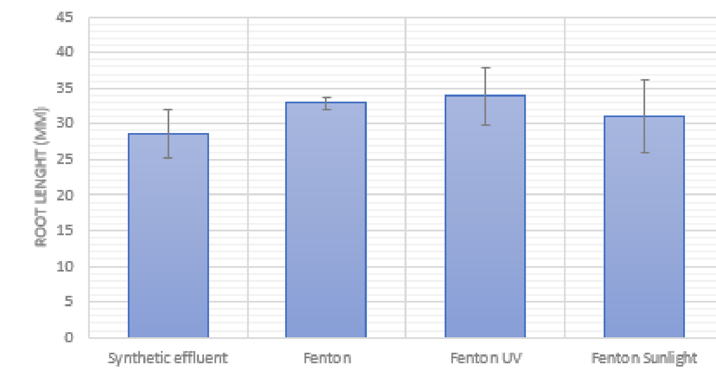
Table 2 – Areas (arbitrary units) of unknowns compounds in treated effluents

	Fenton	Photo-Fenton UV	Photo-Fenton Sunlight
Compound 1	1287,33508	1323,34802	1252,00623
Compound 2	85,90551	92,94711	429,61786
Compound 3	261,51828	283,49539	489,24768
Compound 4	161,37343	170,71240	222,53941

Source: Author (2022)

Figure 5 shows the average root length of *Lactuca sativa* obtained after exposure in each sample.

Figure 5 – Average root length for *L. sativa*



Source: Author (2022)

Amoxicillin does not cause significant effects on germination, but inhibitions of up to 28% on root elongation have been observed.

CONCLUSION

Fenton systems, irradiated or not, presented similar efficiencies in the degradation of AMX, therefore, the degradation of the compound is not directly related to the use of a specific source of radiation;

According to the phytotoxicity analyzes with the test organism *L. sativa* none of the systems had a negative influence on seed germination, however, different effects on root development were observed for each system.

REFERENCES

ALEXY, R. et al. Local use of antibiotics and their input and fate in a small sewage treatment plant - Significance of balancing and analysis on a local scale vs. nationalwide scale. **Acta Hydrochimica et Hydrobiologica**, v. 34, n. 6, p. 587–592, 2006.

ARRUDA, C. J. M. DE; V. F. DE A. S. F. J. M. DE S. J. L. DAS N. S. K. F.; FARO, DOS S. D. Z. C. L. A. DE S. D. F. R. A. Revisão Bibliografica De Antibióticos Beta-Lactâmicos. **Revista Saúde em Foco**, v. 11, p. 982–995, 2019.

BOKARE, A. D.; CHOI, W. Review of iron-free Fenton-like systems for activating H2O2 in advanced oxidation processes. **Journal of Hazardous Materials**, v. 275, p. 121–135, 2014.

GLASSMEYER, S. T. et al. Transport of chemical and microbial compounds from known wastewater discharges: Potential for use as indicators of human fecal contamination. **Environmental Science and Technology**, v. 39, n. 14, p. 5157–5169, 2005.

KÜMMERER, K. Antibiotics in the aquatic environment - A review - Part I. **Chemosphere**, v. 75, n. 4, p. 417–434, 2009. MELO, S. A. S. et al. Degradação de fármacos residuais por processos oxidativos avançados. **Quimica Nova**, v. 32, n. 1, p. 188–197, 2009.

TIBURTIUS, E. R. L.; PERALTA-ZAMORA, P.; LEAL, E. S. Contaminação de águas por BTXs e processos utilizados na remediação de sítios contaminados. **Química Nova**, v. 27, n. 3, p. 441–446, 2004.

TROVÓ, A. G.; MELO, S. A. S.; NOGUEIRA, R. F. P. Photodegradation of the pharmaceuticals amoxicillin, bezafibrate and paracetamol by the photo-Fenton process—Application to sewage treatment plant effluent. Journal of Photochemistry and Photobiology A: Chemistry, v. 198, n. 2–3, p. 215–220, 15 ago. 2008.

WHO. WHO Report on Surveillance of Antibiotic Consumption: 2016-2018 early implementation. [s.l: s.n.].

YANG, Y. et al. Occurrences and removal of pharmaceuticals and personal care products (PPCPs) in drinking water and water/sewage treatment plants: A review. Science of the Total Environment, v. 596–597, p. 303–320, 2017.

ACKNOWLEDGMENT

CAPES
CTA Programa de Pós-Graduação em Ciência e Tecnologia Ambiental
UFABC

Ailton Barbosa Perdão, MSc student; Lúcia Helena Gomes Coelho, Dra.
Center of Engineering, Modeling and Applied Social Sciences, Federal University of ABC (UFABC), Santo André, Brazil
E-mail: ailtonbarbosap@hotmail.com; lucia.coelho@ufabc.edu.br