# Analysis of intensified hydrodynamic cavitation with fenton reagent for the decrease of carbamazepine concentration

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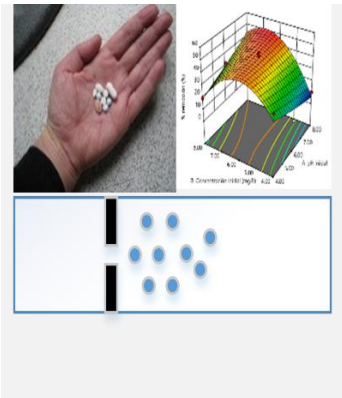
*J,S. Devia Orjuela[1], D,A. Moreno Romero[2], C,A. Guerrero-Cetina[2], A. Lara Ramos[1], N, R. Agudelo Valencia[2], F. Machuca Martinez[1] (1) Universidad del Valle, Calle 13 # 100-00, Cali, Colombia, steven.devia.o@correounivalle.edu.co (2) Universidad Libre, Av 70 # 53-40, Bogota, Colombia*



Throughout time, various authors have worked on advanced oxidation treatment systems for the removal of pharmaceutical-origin contaminants currently present in water. In this study, hydrodynamic cavitation coupled with the Fenton reaction was evaluated as an alternative for decreasing the concentration of Carbamazepine (CBZ) in aqueous solution. The research process was carried out through a $3^2$ factorial experimental design, where the factors and levels of the experimental variables or factors were the initial concentration of CBZ (4 mg/L, 6 mg/L, and 8 mg/L) and the pH of the aqueous solution (4, 6, and 8). The experimental results allowed determining that hydrodynamic cavitation, at initial concentrations of 6 mg/L and a pH of 8, showed higher efficiency by providing 65.23% removal of CBZ and 49.67% TOC (Total Organic Carbon) removal.

## Introduction

Currently, the presence of emerging contaminants, which include multiple commonly used pharmaceutical compounds that have adverse effects on aquatic ecosystems, among these compounds, Carbamazepine (CBZ) can be noted. The research carried out to eliminate CBZ from water has been directed at different techniques such as advanced oxidation processes (AOP).

According to a study “Fenton oxidation of carbamazepine in wastewater with fewer reagents”, it is possible to achieve reductions of 75.86% in Chemical Oxygen Demand (COD) and 45.69% in Total Organic Carbon content (TOC) [1], adjusting pH and contact times. Complete degradation has also been obtained at controlled conditions of temperature (50 °C) and concentration (10 mg/L) in 1 hour [2]. On the other hand, the combination of different techniques for the degradation of contaminants improves the results of each individual technique, such as the "Wetland-Solar Photo-Fenton" coupled system for the degradation of CBZ and diclofenac, achieving a removal of 92% of the CBZ. [6]

Hydrodynamic cavitation (HC) is a green technology. This consists of the oxidation of contaminants in water through the production of hydroxyl radicals that takes place due to the formation and subsequent collapse of cavities or vapor bubbles due to a sudden decrease in the local pressure of the water, [11]. This technique has shown effective results in different physical-chemical wastewater treatment processes and in other applications. The main objective of this project is to carry out the analysis of the hydrodynamic cavitation process intensified with the Fenton reagent at different concentration of Carbamazepine (4 mg/L, 6 mg/L, and 8 mg/L) and the pH of the aqueous solution (4, 6, and 8).

## Material and Methods

A hydrodynamic cavitation prototype was used that has a 1.0 hp pump and 90 L reaction tank. Through a factorial experimental design with two factors (initial pH: 4, 6 and 8, and carbamazepine concentration in the aqueous solution: 4, 6 and 8 mg/L) for three levels of each factor or process variable, a total of 9 experiments were obtained that were carried out in triplicate, each test lasted 60 minutes. The TOC analysis was carried out in a Shimaduz LC-2030C Plus Prominence equipment and the CBZ concentration in a Thermo Genesys 10Sm spectrophotometer, the pH was measured in a Methrom 780 potentiometer, sampling was done every 10 minutes.

## Results and Discussion

The maximum percentage of CBZ removal achieved was 65.23% for pH 8 and initial CBZ concentration of 6 mg/L. With respect to COT trials, the results are similar. For an initial pH between 6 and 8, removals greater than 40% are achieved. It is also observed that the initial concentration of CBZ influences the removal of this contaminant, which may be due to the ionization state of the molecule and also due to the abundance of OH radicals.

It is important to note that the Fenton reagent produces a removal of 14% while hydrodynamic cavitation does not show effectiveness in the degradation of this compound at the operating conditions of the present research. However, the combination of both techniques generates

degradations greater than 60%, as previously mentioned. Figure 1 shows that pH is the variable that has the greatest influence on the percentage of CBZ removal. When the concentration of CBZ is low, the probability of encounter between the contaminant and the radicals decreases, and recombination of the radicals can take place to form water, so that they lose their oxidizing effect.

On the other hand, the pKa of CBZ is 13.9, so this compound will be found in its ionic form with a positive charge for a pH lower than its pKa, a fact that increases the force of attraction between the ionized contaminant and the OH radicals.
So, for the pH range used in the tests, CBZ was in its ionic form and although all the experiments were carried out at a pH lower than the pKa, the recombination of the radicals at alkaline pH affects their performance for pH greater than 8.

Although each of the tests was carried out for one hour, from minute 30 the variations in the concentration of CBZ and TOC are not significant, the short retention time required represents an operational advantage from the perspective of energy consumption and size of the units. of treatment.

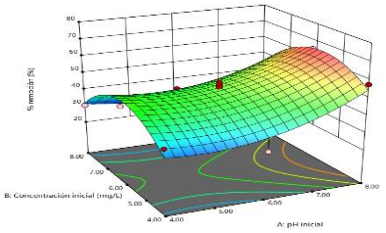



**Figure 1.** response surface for percentage removal of CBX by pH and Initial concentration.

**Table 1.** Results of CFX and TOC concentration decrease.

| pH | Concentration CBZ (mg/L) | % CFX | % TOC |
|---|---|---|---|
| 4 | 6 | 44.8 | 38.73 |
| 4 | 8 | 30.4 | 19.26 |
| 4 | 4 | 37.5 | 31.08 |
| 6 | 6 | 51.7 | 41.48 |
| 6 | 6 | 46.7 | 45.48 |
| 6 | 6 | 49.5 | 47.48 |
| 6 | 4 | 27.5 | 4.82 |
| 6 | 6 | 50 | 49.67 |
| 6 | 6 | 48.7 | 47.67 |
| 6 | 8 | 33.7 | 31.41 |
| 8 | 4 | 57.5 | 10.11 |
| 8 | 8 | 41.25 | 40.92 |
| 8 | 6 | 65.23 | 45.29 |

## Conclusions

The concentration of CBZ is decreased and proportionally the concentration of TOC is decreased, consequently, the CBZ that is transformed is mostly mineralized and eliminated from the aqueous solution and It can be inferred that hydrodynamic cavitation intensified with Fenton Reagent achieves more favorable results compared to other CBZ degradation processes present in water. Not only for efficiency, but also for its economic and technical accessibility, which makes this process an outstanding option.

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***References***

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