

Ozonation's Significance in Safeguarding the Environment and Human Health: A  
Comparative Examination of Iberoamerica and Perspectives.

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**Abstract**

Ozonation is an established advanced technique for water and wastewater treatment, widely recognized for its effectiveness in achieving disinfection, removing micropollutants, as well as eliminating color and odor, among other benefits. Its importance is underscored by the fact that many cities worldwide incorporate ozonation as a crucial component of their water and wastewater treatment processes. Over the past decades, the scientific community has made significant contributions to the field of ozone science, with noteworthy input from Iberoamerican countries. South America has also played a significant role in advancing global knowledge in this area. However, the absence of stringent regulations has limited the widespread application of ozonation in this region. Currently, the outlook is changing, with some countries moving towards the development of new regulations. This shift opens up substantial opportunities for companies, emerging researchers, and, most importantly, environmental protection in these nations.

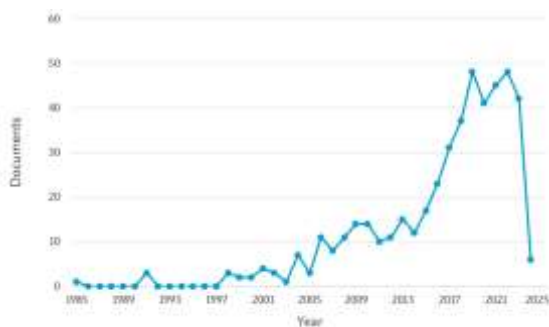
**Introduction**

Ozonation is a worldwide established technique used for the treatment of water and wastewater (Dogruel et al., 2020). The direct molecular ozone attack combined with the indirect reaction through radicals makes ozonation a powerful tool not only to degrade organic molecules but also for the inactivation of diverse microorganisms (von Gunten, 2003).

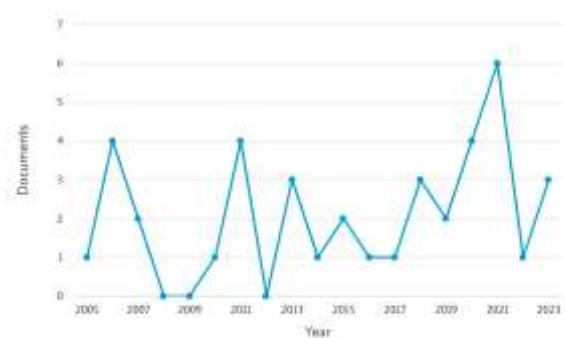
When installed in a wastewater treatment plant (WWTP) as a tertiary treatment, ozonation promotes the polishing of the secondary treated effluent, thus guaranteeing its quality for safe disposal in the environment and even for reuse (Malvestiti et al., 2022). This approach is widely used in developed countries, where most WWTPs have ozone as part of the treatment trains in tertiary treatments (Sommaggio et al., 2022). However, the adoption of ozonation in developing countries, such as Latin American countries, is still very limited to certain applications.

The pace of research production in Latin American countries in the field of ozonation does not match the same level of public/private investments or installations of ozone treatments. In the last decades, some countries such as Brazil, Argentina, Colombia, and Chile have produced a significant quantity of specialized research in the field of ozonation (Figure 1). Brazil stands out with the highest number of publications in the last decade, while Colombia has also experienced a significant increase in this area in recent years (Figure 1).

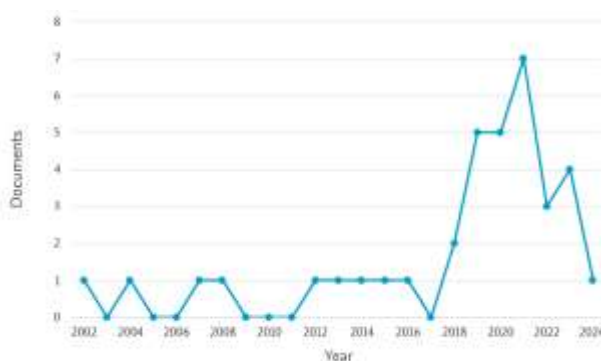
Brazil



Argentina



Colombia



Chile

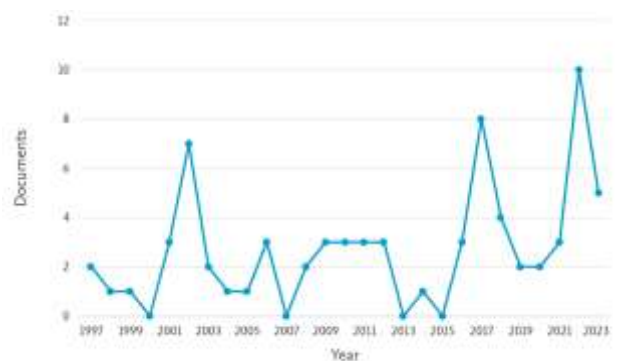
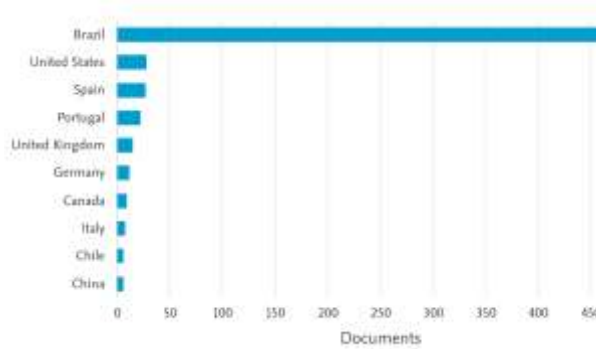


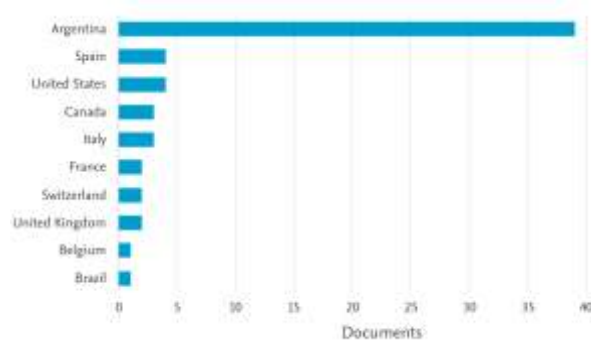
Figure 1 – Number of scientific documents published in the last decades in some Latin-American countries (source Scopus – January of 2024).

One important factor that has driven some Latin American countries in the search for water and wastewater innovation, particularly in the field of advanced oxidation and ozonation, is the collaborative efforts in the last three decades with specific countries such as Spain, Portugal, and the United States. Figure 2 presents the number of scientific documents published by Brazil, Argentina, Colombia, and Chile with their collaborating countries. This figure illustrates the contributions of those countries in technology transfers among nations in the last decades. Many countries have collaborated in ozone science in Latin America, with notable contributions from Spain, Portugal, and the United States

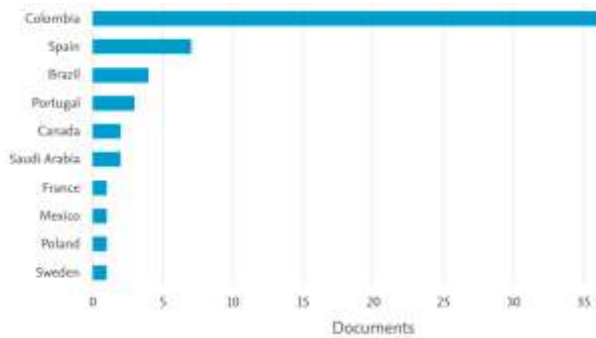
### Brazil



### Argentina



### Colombia



### Chile

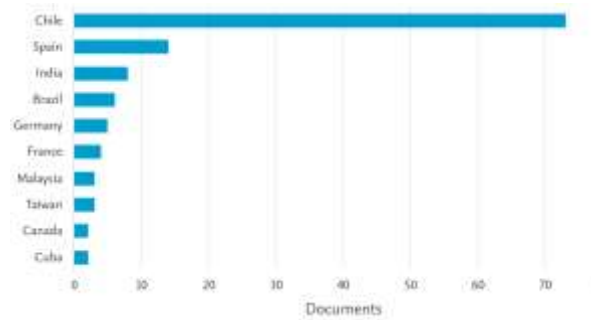


Figure 2 – Number of publication in the last decades of some Latin-American countries with their respective collaborators (Source Scopus – January of 2024).

## **Legislation aspects**

Unfortunately, the legislation in Latin American countries does not support technology development adequately. Many of the regulations applied to water and wastewater treatment are limited to a few parameters and are not as strict as those in developed countries ((Brazil), 2007). This situation hinders the application of many advanced technologies that have been developed in Latin American countries. This gap may result in an enormous lack of competitiveness among regional companies. When legislation is enacted belatedly, these companies have to acquire technology from abroad, where it has been applied for years or even decades.

## **Environmental aspects**

Brazil is one of the case studies that shows what happens when policies do not align with technological development. While many researchers in Brazil dedicate themselves to producing environmental solutions such as water and wastewater treatment based on ozonation, these techniques cannot be applied in Brazil due to the lack of legislation obliging companies to better protect the environment (Moura et al., 2020). Most of the technology produced in Brazil regarding ozonation is published and used by many companies around the world, making the investment in research not directly beneficial for Brazilian companies. The result is the mismanagement of public funds and a country with very poor environmental protection, despite having many specialists in the subject.

## **Conclusions**

Despite the contribution of Latin American countries to the development of ozonation and other advanced oxidations, their researchers are not being directly utilized in their countries due to the lack of environmental policies. This imbalance between research and application is causing not only the mismanagement of public resources but also missing the opportunity to become a region with acceptable environmental protection.

## Acknowledgments

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