Management of Anticancer Drugs on Wastewaters treated at Puerto Nuevo Treatment Plant of "Autoridad de Acueductos y Alcantarillados de Puerto Rico"

Author: Paula M. Colón De Jesús
Advisor: Christian Villalta Calderón Ph.D.
Graduate Program in Environmental Management

Abstract

Cancer is one of the leading causes of death worldwide, and its treatment often involves the use of anticancer drugs. However, these drugs can enter the environment through various pathways, including excretion from patients, disposal of unused drugs, and discharge from healthcare facilities. This project will discuss the occurrence, treatment, and ecological risks associated with anticancer drugs in wastewater and natural environments.

Introduction

Several studies have reported the presence of anticancer drugs in wastewater and natural environments. In a study conducted in the United States, 16 out of 19 commonly used anticancer drugs were detected in wastewater treatment plant effluent, and their concentrations ranged from ng/L to µg/L. Similarly, a study in Europe detected several anticancer drugs, including cyclophosphamide, in river water samples.

The impact of anticancer drugs on wastewater and the environment is not well understood, but research has shown that these drugs can significantly affect aquatic life. For example, one study found that exposure to low concentrations of the anticancer drug tamoxifen can affect the behavior and reproduction of zebrafish. Similarly, exposure to the anticancer drug 5-fluorouracil has been shown to affect the growth and survival of algae and aquatic plants.

There are several reasons why anticancer drugs are particularly concerning when they end up in wastewater. For one, these drugs are designed to be toxic to cancer cells, which means they can also be toxic to other living organisms. Additionally, many anticancer drugs are not readily biodegradable, meaning they can persist in the environment for long periods. Finally, the concentrations of these drugs in wastewater can be quite low, which can make it difficult to detect and manage their effects.

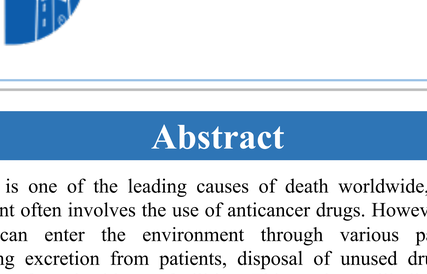

Figure 1
Flowchart of Movement of Anticancer Drugs to Water Bodies

Problem

Anticancer drugs are a class of drugs that are designed to kill cancer cells or slow their growth. These drugs are often administered orally or by injection and work by targeting specific molecules or pathways involved in cancer development and progression. However, many of these drugs are not completely metabolized by the body and are excreted in urine or feces. This means these drugs can end up in wastewater, which can then be released into the environment.

Objectives

- Propose new techniques to achieve and ensure the elimination of pharmacological waste, precisely anticancer drugs, which can contain radiological wastes.
- Lower the environmental impact on natural water systems.
- Propose a new model for better management and treatment of wastewater by the *"Autoridad de Acueductos y Alcantarillados de Puerto Rico."*

Methodology

Law No. 79 for the Control of Radiation in Puerto Rico of June 24, 1965, as amended, specifies in section C the regulation of waste by discharge through sanitary sewer systems. [2] This law takes into consideration the disposal on the part of the licensee, hospital, entity, etc. However, the discharge in used water with respect to patients needs to be taken into consideration.

In Colombia was found a very similar environmental problem. They conducted a study on a wastewater plant located in Cali, Colombia. "The presence of pharmaceutical compounds of therapeutic groups antiepileptics, hypolipemic agents, anti-inflammatory analgesics, and tranquilizers were evaluated in three samplings campaigns; besides, the removal efficiency chemically enhanced primary treatment with coagulation, flocculation, and sedimentation processes in the wastewater treatment plant of Cali city (Colombia) was estimated.

After the treatment, most compounds had removal efficiency lower than 30%, while paracetamol and naproxen had the highest removal of 98.1% and 57.1%, respectively. These removal efficiencies could be linked not only with the coagulation-flocculation process, which is fair for lipophilic substances but also with the biodegradation action of bacteria present in the wastewater." [1] With this information, we can confirm that it is a severe problem that is not getting the attention it should, and it is happening not only in the United States but worldwide. It might not be seen as a big issue in the present, but this represents a significant threat in the long run, causing antibiotic and certain medicines resistance, developing new diseases in humans, altering, or killing specific ecosystems, etc.

Puerto Nuevo Treatment Plant of *"Autoridad de Acueductos y Alcantarillados de Puerto Rico"* located at Carretera #2 Km. 2 Ave. John F. Kennedy, in the Municipality of San Juan.

Currently, Puerto Nuevo Plant receives wastewater from the San Juan area, including the principals and biggest hospitals. This plant operates under the National Pollutant Discharge Elimination System (NPDES). [3] The treatment level of this plant is primary.

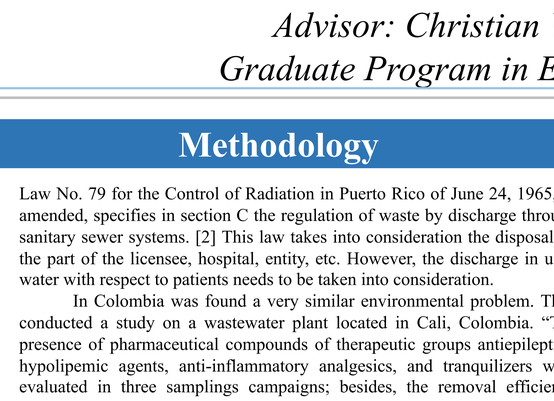

Figure 2
Overview of Puerto Nuevo Wastewater Treatment Plant

The treatment system consists of an influent pumping station, mechanical grating bars, primary clarifiers, sludge handling facilities, and disinfection by chlorine injection. The effluent is then discharged into the Atlantic Ocean. The sludge handling facilities consist of gravity thickeners, belt filter presses for dewatering, and an incinerator for biosolids disposal.

Results and Discussion

The treatment plant of Puerto Nuevo in the municipality of San Juan, PR, is a Primary Treatment plant. They do measure the radiation level in the water. Still, they don't have any procedure to remove radiation or pharmaceutical products from the water treated before it goes back to the ocean. The same situation is found with the rest of the wastewater treatment plants in Puerto Rico.

Electrocatalysis can be defined as the heterogeneous catalysis of an electrochemical reaction, which occurs at the electrode–electrolyte interface and where the electrode plays the double role of electron donor/acceptor and catalyst. An electrode acts as a catalyst for reactions since it participates either by providing sites for the adsorption of intermediates (Internal Transfer Mechanism) or as an electron carrier that transfers the charge by tunnel effect to species at the interface (Mechanism of External Transfer). In the last decades, electrocatalysis has risen due to its wide field of application, including the environment. In the environmental area, electrochemical technologies are considered chemically green or friendly to the environment since the primary reagent is the electron; therefore, several books and reports have been generated emphasizing the elimination of organic and inorganic pollutants in wastewater and water for human consumption. [5]

Wastewater treatment plants in Puerto Rico should implement the process of Photo Electrocatalytic Oxidation. It can start with the Puerto Nuevo wastewater treatment plant as a pilot plant, considering that it can be a high-risk plant since it only does primary treatment and is the plant that receives all the wastewater from the municipality of San Juan, which is the municipality that contains the biggest hospitals in the island, including two that are specialized on cancer.

A way to implement this process of photo electrocatalytic oxidation can be done using the equipment manufactured by the company SynerTech SAS located in Colombia, which can be utilized by placing this equipment as a final treatment right before discharging this water into the Atlantic Ocean. The Model 18-23 can treat up to 70 M^3/Hour.

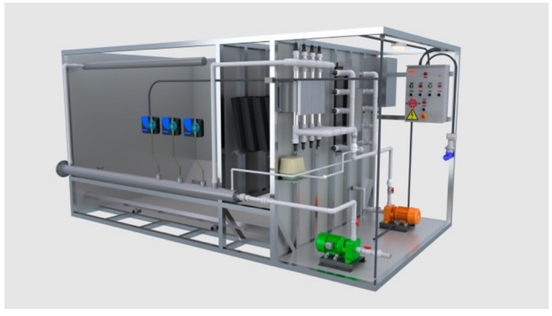

Figure 3
Design of models 18-23 from SynerTech SAS Water Technologies

Figure 7
Model 18-23 from SynerTech SAS Water Technologies already manufactured

This technology is used for virtually impossible substances to remove from water without oxidation. The residual products formed by oxidation can be treated by absorption, biological degradation, sedimentation, or membrane filtration. Synertech leads the implementation of oxidation technology in processes such as chemical oxidation and advanced oxidation at more complex levels. It is recommended as a complementary and improved process in industrial wastewater treatment plants. Advanced Oxidation Processes (POAs) or Advanced Oxidation Processes are characterized by taking advantage of the high reactivity of the hydroxyl radical (OH·) as an oxidizing agent (do not confuse the radical with the hydroxyl ion, OH-) to oxidize the organic matter dissolved in the water until its mineralization. [6]

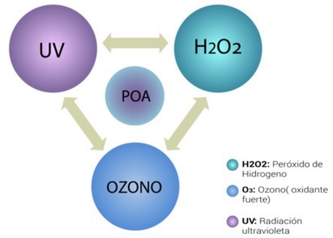

Figure 8
Diagram of Advanced Oxidation Processes (POA)

Conclusions

The process of Photo Electrocatalytic Oxidation has already been implemented in many industries, especially pharmaceutical industries, to ensure they eliminate any pharmaceutical component in wastewater. It has been proved that this process work and is efficient. The same can be applied to municipality systems doing the proper research and analysis to bring it to a bigger scale and be able to complete the needs of water treatment of the plant. Implementing this process in our wastewater treatment plants will ensure that no anticancer drug, pharmaceutical component, or any other chemical that is not removed by normal processes like screens, sedimentation, UV light, or adding chlorine will be present on the effluent that will be liberated on the Atlantic Ocean. As a result, we will ensure that the water released will not harm any ecosystem, that will not make any environmental impact, that will not affect any human directly or indirectly.

Future Work

- Identify the amount of water that needs to be treated by the hour at the Puerto Nuevo Plant.
- Analyze how many models 18-23 the plant will need to start the pilot project.
- Proceed with tests to identify if the process is successful.
- Analyze what the cost will be and bring the inversion fro the project to the government of Puerto Rico for approval.

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