# INACTIVATION OF *E. COLI* AND ANTIBIOTIC RESISTANCE BY UVC/CHLORINE FOR THE FEEDING OF AQUAPONIC SYSTEMS WITH REGENERATED WASTEWATER.

Universidad Rey Juan Carlos

IQA Grupo de Ingeniería Química y Ambiental

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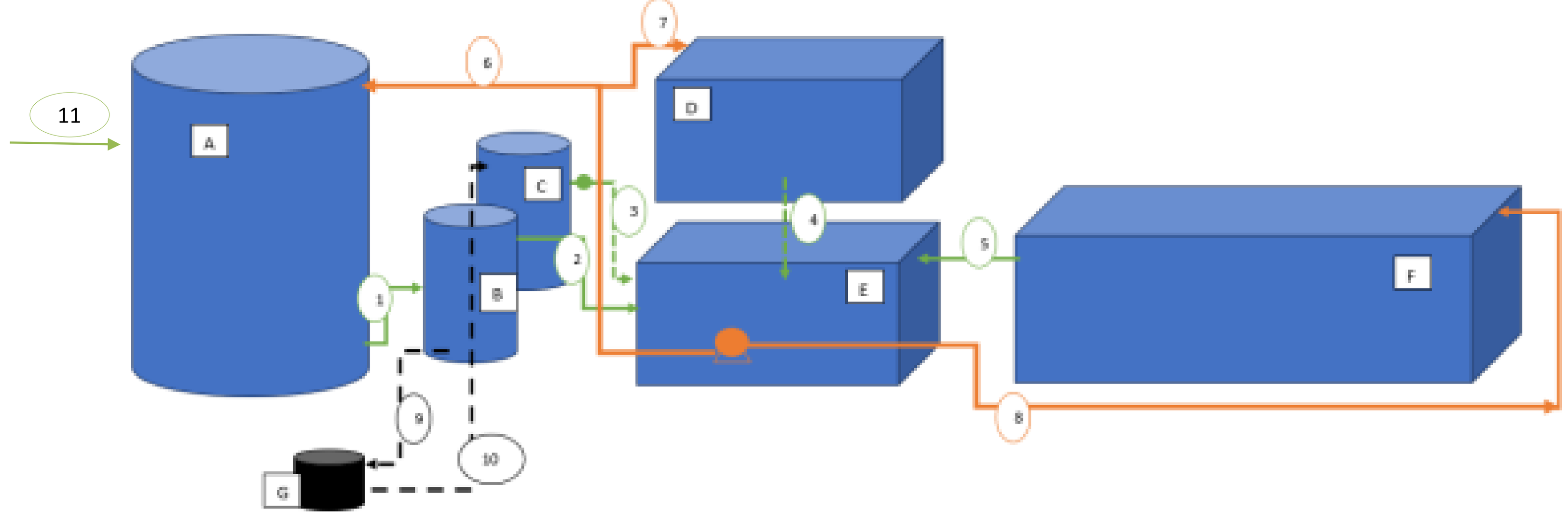
## INTRODUCTION

Recirculating aquaculture systems (**RAS**) involves the accumulation of waste products and microbial load. To maintain optimal growth of plants and fish in aquaponics, filtration and contaminant removal systems must be implemented. A RAS advantage is the reduction of water requirements compared to raceway or pond aquaculture systems. To go further and for this purpose, this work has evaluated the efficacy of photolysis process in bacterial inactivation with the goal of being applied as a **regenerated wastewater treatment to be reused in the aquaponics system**.

Some of the most effective methods used are Advanced Oxidation Processes (AOP), where oxidants such as hydroxyl radicals are formed to oxidize organic contaminants and microorganisms. Among these methods, the combination of ultraviolet radiation (UVC) with oxidizing agents such as chlorine or hydrogen peroxide ($H_2O_2$) stands out. This study focuses on bacterial inactivation in water for reuse purposes using UVC/Cl and UVC/$H_2O_2$ AOPs, forming mainly hydroxyl free radicals and chlorine, in a small-scale reactor.

The use of oxidizing agents is supposed to increase the efficacy of this process to be applied as a tertiary treatment in a sewage treatment plant.

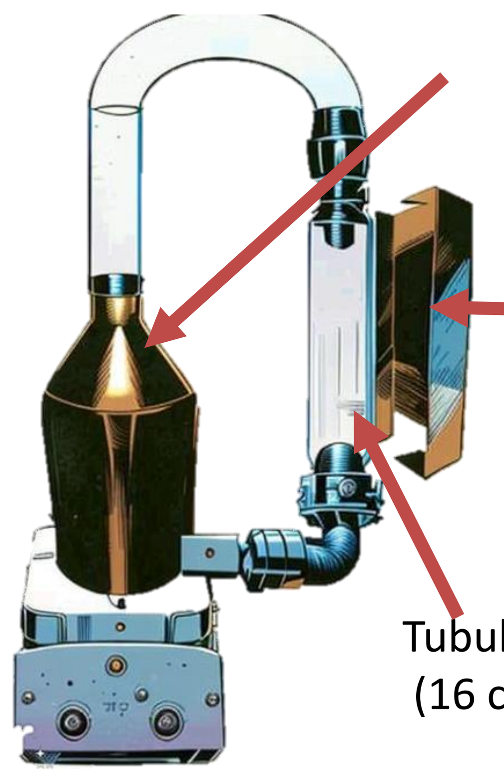



Aquaponics system diagram. Supplier of the system: Green In Blue

A. Aquaculture tank.
B. Settle down.
C. Aerobic digestor.
D. Biological filter.
E. Sump and water pump.
F. Hydroponic tank.
G. Purgue of settler.

-Stream 1: Outlet of aquaculture tank.
-Stream 2: Settler supernatant outlet.
- Stream 3: Aerobic digester outlet. It opens manually when the output level is reached. output level.
- Stream 4: Outlet of the biological filter tank. Occurs by siphon through a tidal system every 20-30 minutes.
- Stream 5: Outlet of hydroponic tank.
- Stream 6: Inlet of aquaculture tank.
- Stream 7: Inlet of the biological filter.
- Stream 8: Inlet of hydroponic tank.
- Stream 9: Purging of the settler. The sediment is manually opened 1 to 3 times per week according to the requirements.
week according to requirements.
- Stream 10: Inlet to the aerobic digester.
- Stream 11: Regenerated wastewater input into the aquaponic system.

## METHODOLOGY



1L sterile saline water at 0.9% with $10^6$ CFU/mL bacterial inoculum

4 UVC mercury lamps emitting at 254 nm

Tubular reactor (16 cm x 3 cm)

By varying the position of the lamp with respect to the photoreactor and modifying the number of lamps lit, different levels of radiation intensity can be obtained.
1L of saline water solution is introduced into the tank and the bacteria is inoculated with a concentration of $10^6$ CFU/mL and the oxidizing agent is added.
Counting is done by plate seeding with LB Agar for *E. coli* and TSA Agar by supplying 70 mg/L TSA of Vancomycin. It is incubated for 24 h at 37ºC. The slopes of the bacterial inactivation curves are used to calculate the reaction constants from a pseudo first order fit.
Free chlorine and residual peroxide were measured photometrically at the end of each reaction to determine their degradation and permanence in the water.
It is known that chlorine would generate toxicity for fish in the aquaponics system, so it may be necessary to install an active carbon filter before entering the aquaponic system in case there is chlorine remaining after treatment.

## TESTS


| UVC (254 nm) |
|---|
| Radiation (W/m²) |
| 2.89 |
| 4.79 |
| 7.89 |
| 34.42 |
| 82.41 |

| Oxidizing compound (ppm) | |
|---|---|
| Free chlorine | Hydrogen Peroxide |
| 0.1 | 20 |
| 0.17 | 50 |
| 0.25 | |
| 0.5 | |

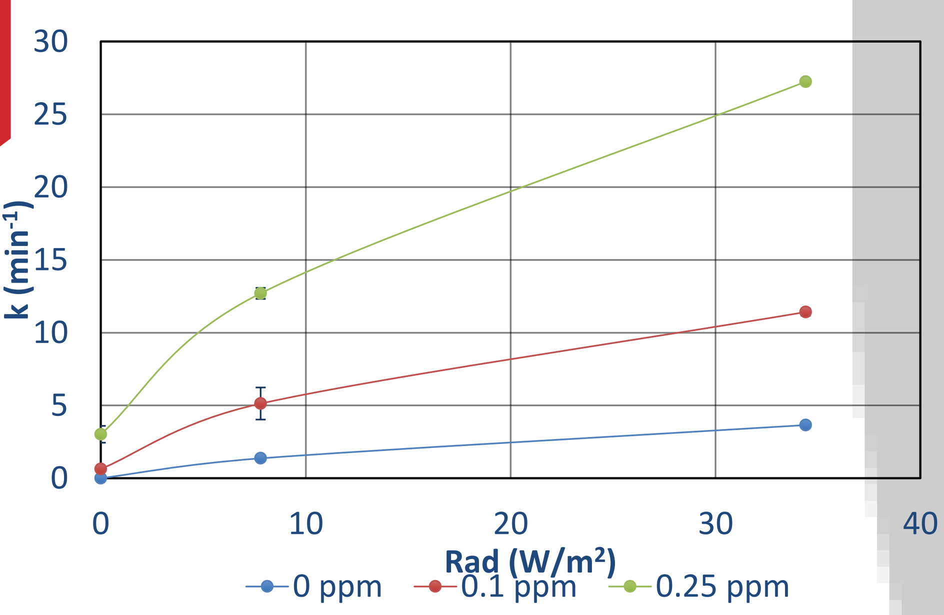
**Pollutants**

- *Escherichia coli*
- Resistant bacteria to the antibiotic Vancomycin (ARB-Van)

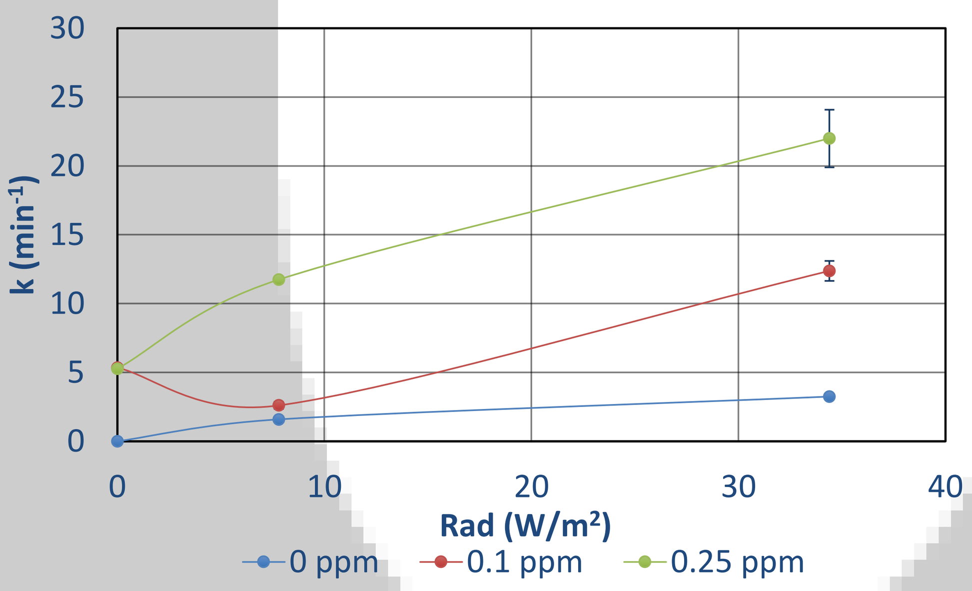
**Kinetic constants calculation (k)**
Log (CFU/mL) = k · t (min)

## RESULTS

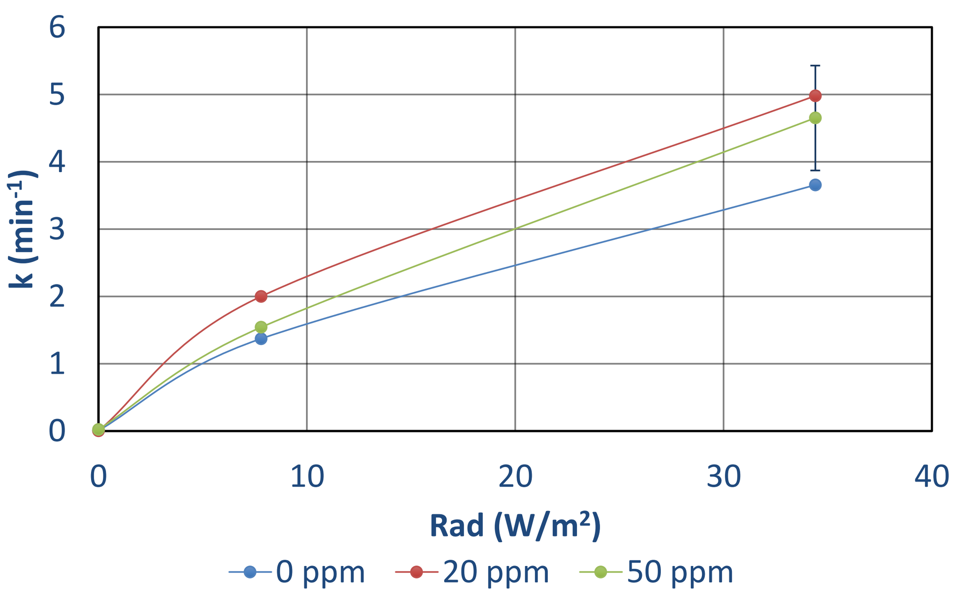
### *E. coli,* UV-Cl Process



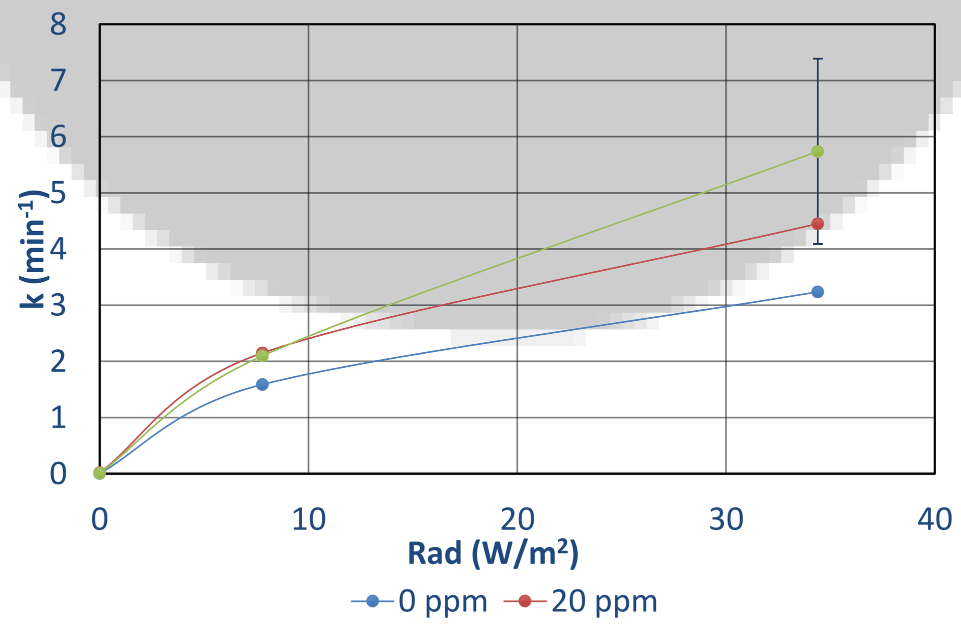

### ARB (Van), UV-Cl Process




### *E. coli,* UV-$H_2O_2$ Process




### ARB (Van), UV-$H_2O_2$ Process




In the case of *E. coli* inactivation processes, the kinetic constant increases linearly with irradiance and chlorine concentration. However, in the non-irradiated chlorination processes during ARB (Van) inactivation, no further degradation is observed with increasing chlorine concentration. This shows that the use of UV-C radiation is necessary to degrade this type of contaminant. Residual free chlorine at the end of each experiment comprises values between 0.06 and 0.09 ppm, at an initial chlorine concentration of 0.1 ppm and values of 0.06 and 0.17 ppm for an initial concentration of 0.25 ppm, depending on the light conditions.
In the case of UV-$H_2O_2$ processes, they have shown to be less effective resulting in lower and similar kinetic constants despite the increase in concentration of the compound.

## CONCLUSIONS

In conclusion, the most efficient AOP for the inactivation of the bacteria studied is the combined UV-Chlorine process. However, the degradation of chlorine during the photolysis processes has been measured, the final free chlorine concentration has always been higher than 0.02 ppm, taking into account that the concentration of toxic chlorine becomes visible for concentrations higher than this value for the health of the aquatic environment, an active carbon filter should be installed before introducing the regenerated water into the aquaponic system.

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