Degradation Kinetics of Antibiotic Resistance Genes using Hydroxyl Radical and Sulphate Radical

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1 Introduction

- Antibiotic resistance (AR) is a 'silent' pandemic[1].
- Wastewater treatment plants (WWTPs) are identified as reservoirs and sources for the release of Antibiotic-resistant bacteria (ARB) and antibiotic resistance genes (ARGs) into water sources[2].

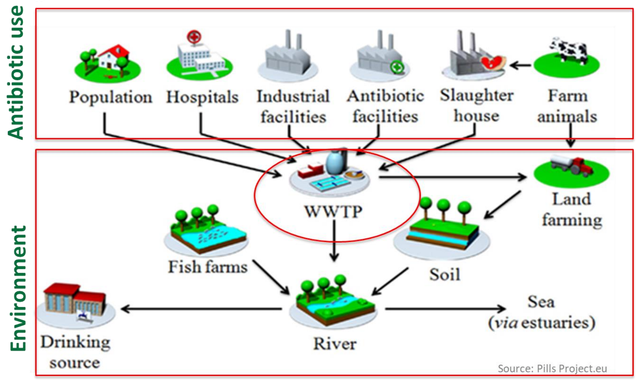


Figure 1: *WWTPs as sources of AR dissemination[2]*

Motivation for the study

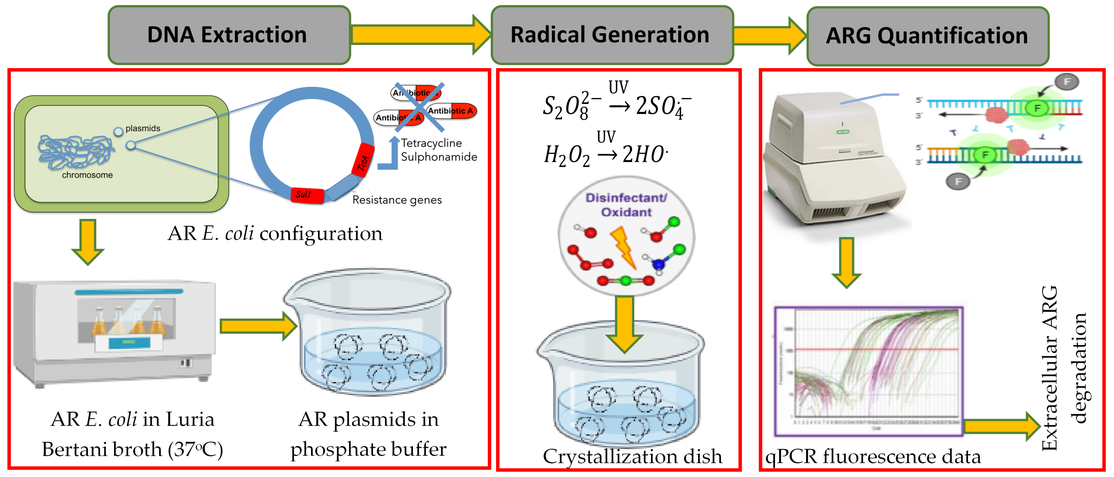
Conventional chlorination and UV irradiation inactivate ARB but **ARGs are not effectively degraded**. Advanced oxidation processes (AOPs) with strong oxidizing power of hydroxyl radical ($HO^{\cdot}$) and sulphate radical ($SO_4^{\cdot-}$) are promising technologies for ARGs degradation[3]. The comparative kinetics of $HO^{\cdot}$ and $SO_4^{\cdot-}$ AOPs in AR mitigation via ARG degradation and horizontal gene transfer prevention remains unexplored.

2 Research Questions

This study addresses the following questions:

- What is the rate of extracellular ARGs degradation during $HO^{\cdot}$ and $SO_4^{\cdot-}$ treatments?
- Does $SO_4^{\cdot-}$ readily degrade ARGs than $HO^{\cdot}$ under typical environmental conditions?
- Is DNA degradation observed by qPCR a good measure of the loss of biological activities of ARGs ?

3 Methods



4 Results

- The rate of ARG degradation was higher with $SO_4^{\cdot-}$ AOP (Figure 2).
- 0.2 mM persulphate only achieved between 1-2 log ARG degradation for all amplicons (Figure 2).
- > 5 log ARG degradation achieved for amplicons >210 bp with UV, UV/H_2O_2 and UV/persulphate.

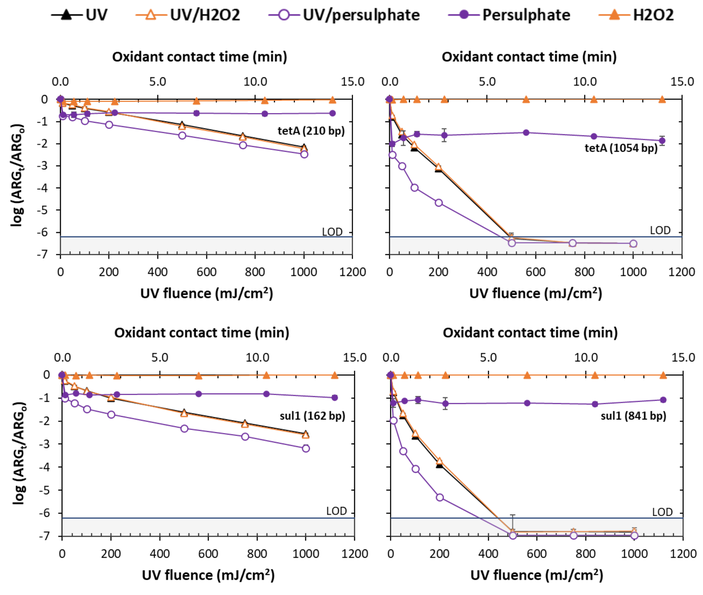


Figure 2: *ARG degradation kinetics using 0.2 mM oxidant (pH 7)*

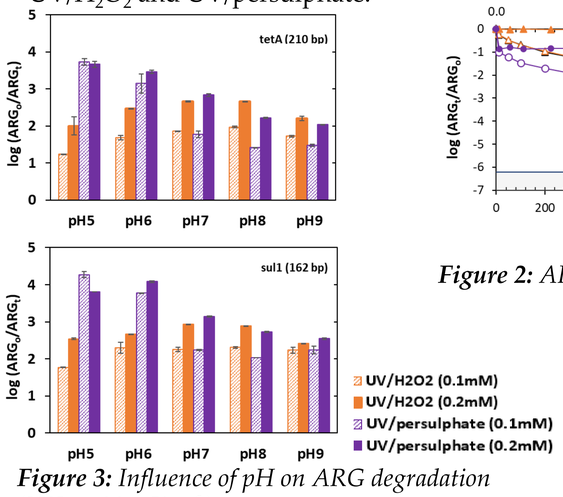


Figure 3: *Influence of pH on ARG degradation (UV = 500 mJ/cm²)*

- ARG degradation by $SO_4^{\cdot-}$ decreases as pH increases while $HO^{\cdot}$ shows optimum ARG degradation near-neutral pH (Figure 3).
- pH shows similar influence on degradation regardless of oxidant concentration (Figure 3).

5 Conclusions

- $SO_4^{\cdot-}$ AOP resulted in higher ARGs degradation than $HO^{\cdot}$ AOP and conventional UV treatment.
- $SO_4^{\cdot-}$ AOP is most effective for ARG degradation under acidic pH while $HO^{\cdot}$ AOP is most effective between pH 7 and 8. Thus, $SO_4^{\cdot-}$ and $HO^{\cdot}$ AOPs can serve as a barrier against AR dissemination if optimum treatment conditions are maintained.
- ARG quantification observed by qPCR is dependent on the monitored amplicon length and the nucleotide contents of measured ARG.

6 Future Work

- Determine the biological activity of AR plasmids exposed to $HO^{\cdot}$ and $SO_4^{\cdot-}$ treatments.
- Assess the influence of dissolved organic matter on the ARG degradation kinetics of $HO^{\cdot}$ and $SO_4^{\cdot-}$ AOPs.
- Estimate the second-order degradation rate constants.

7 References

[1] Monnet and Harbarth, 2020. Euro Surveill. DOI: 10.2807/1560-7917.ES.2020.25.45.2001886.

[2] Stalder *et al.*, 2012. Front. Microbiol. DOI:10.3389/fmicb.2012.00119.

[3] Czekalski et al., 2016. 2012. *E S&T*, DOI: 10.1021/acs.est.6b02640.

8 Acknowledgements

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