Nanomaterials and photonic solutions: Novel 'at-source' approaches to stop hospital-derived priority substances reaching the sewer network

Manuel-Thomas Valdivia Moya

University of the Highlands and Islands, Institute of Health Research and Innovation, Division of Biomedical Sciences

manuelthomas.valdivia@uhi.ac.uk | www.hydronationscholars.scot/scholars/manuel-thomas-valdivia

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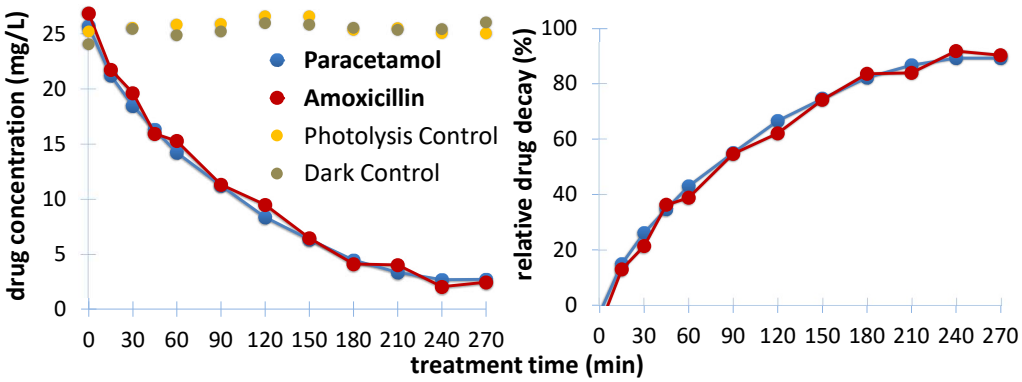
Introduction

- Trace or ultra-trace concentrations of specific drugs in hospital wastewater can have toxic effects.
- Efficient wastewater treatment is urgently needed to eliminate persistent pharmaceuticals, prevent potential accumulation in food chains and future risks to human health.
- Photocatalysis is a promising approach to remove drugs and their metabolites via light-promoted synthesis of reactive oxygen species (ROS), which can oxidise and eliminate organic drug compounds.
- Optimisation of photocatalytic nanomaterials is necessary to enhance ROS generation and accelerate drug elimination.
- Immobilisation of photocatalysts onto porous carbonaceous supports may improve suitability of this technique for a flow-through treatment setting for hospital wastewater.

Results

~90 % drug decay after 4 h UV-light exposure and zinc oxide as photocatalyst



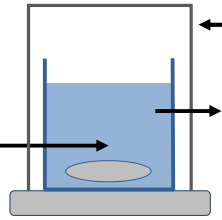
- Photolysis control to test stability of drug/catalyst against UV-light.
- Dark control to test drug removal via adsorption onto the catalyst.

Methods

Test drugs: Amoxicillin and **Paracetamol**

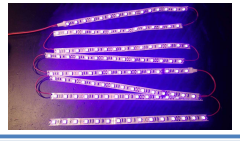
Test nanomaterial: Zinc Oxide (ZnO)
Inexpensive, UV-light efficient (wide band gap 3.37 eV)

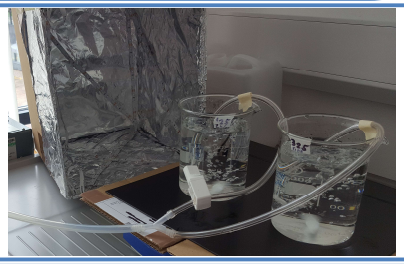
Tap water 500mL pH 7 + 1 g/L ZnO + 25mg/L drug



Box coated with aluminium foil and adhesive 60 W UV LED strips (365-370nm)

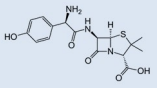
Sampling intervals:
15 – 30 min for 5 h

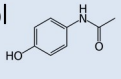


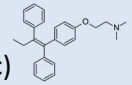


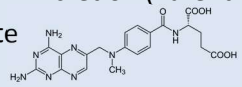
Selected pharmaceuticals

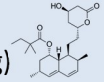
Environmental Risk factor (RQ) -> Persistence in wastewater (physico-chemical properties) -> Excretion (Parent vs metabolite) -> WWTP removal -> Prescribing data

Amoxicillin (Antibiotic) 

Paracetamol (Analgesic) 

Tamoxifen (Cytostatic) 

Methotrexate (Cytostatic) 

Simvastatin (Lipid-lowering drug) 

+ active metabolites

Future

- Use electron paramagnetic resonance spectroscopy (EPR) to confirm free radical species generation involved in drug degradation.
- Immobilise photocatalytic nanomaterials on porous (carbonaceous) structures via high-temperature calcination in a furnace.
- Optimise HPLC-MS and Raman spectrometry approaches to determine drugs at relevant concentrations for hospital wastewater (≥ 1 ng/L).
- Determine acute and chronic toxicity of wastewater post photocatalytic treatment via impact on human endothelial cell lines, daphnia, microtox, microalgae.

NHS Highland | Scottish Water | SEPA Scottish Environment Protection Agency | HIE Highlands and Islands Enterprise | POLYCAT

Supervisory Team
Prof Ian Megson, Prof Alistair Kean, Dr Mark Taggart, Dr Szablocs Pap

eri environmental research institute | University of the Highlands and Islands Oilthigh na Gàidhealtachd agus nan Eilean