

**Interreg**  
Baltic Sea Region



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SUSTAINABLE WATERS

**AdvIQwater**

# Application of advanced oxidation processes for solar-driven photodegradation of pharmaceuticals

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[interreg-baltic.eu/project/advIQwater/](https://interreg-baltic.eu/project/advIQwater/)



**GDAŃSK UNIVERSITY  
OF TECHNOLOGY**



# Advanced Oxidation Processes

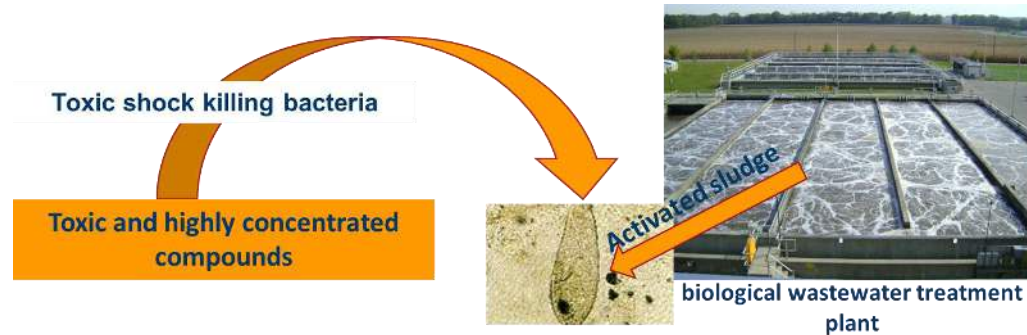


In-situ production of hydroxyl radicals ( $\text{OH}\cdot$ ) and sulfate radicals ( $\text{SO}_4^{\cdot-}$ )

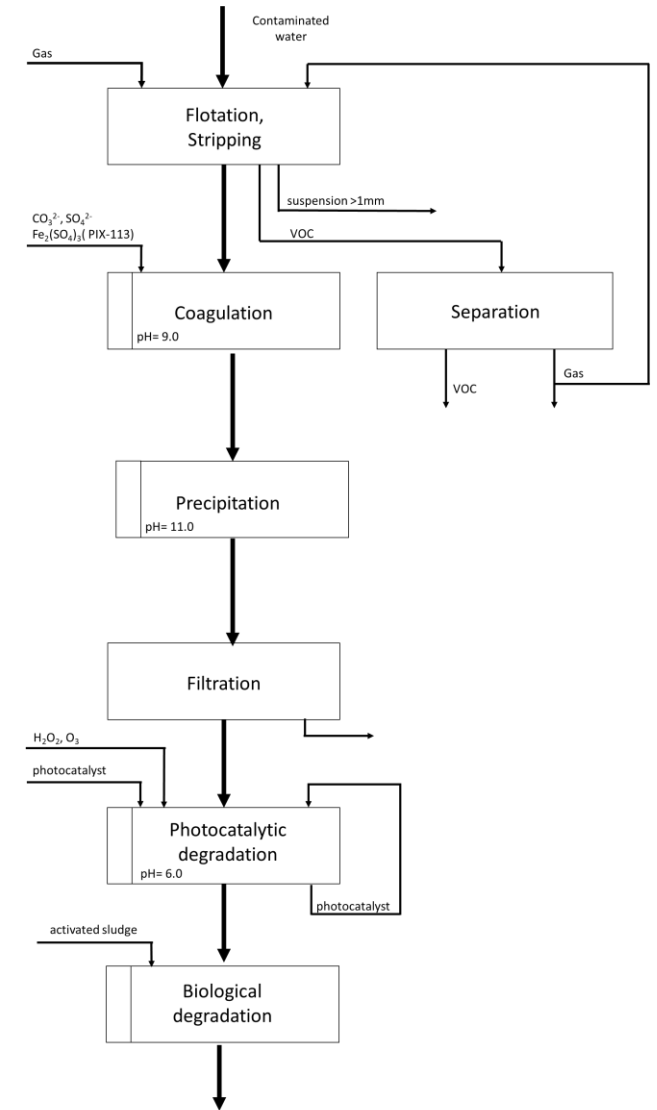
oxidizing agent	oxidation potential [V]
hydroxyl radicals	2.89
sulfate radicals	2.80
Fenton's reagent	2.76
ozone	2.07
hydrogen peroxide	1.78
hypochlorous acid	1.49
chlorine	1.36

# Advanced Oxidation Processes

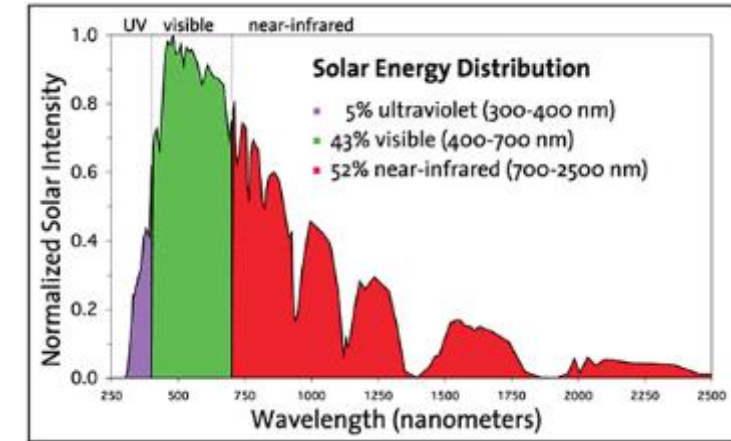
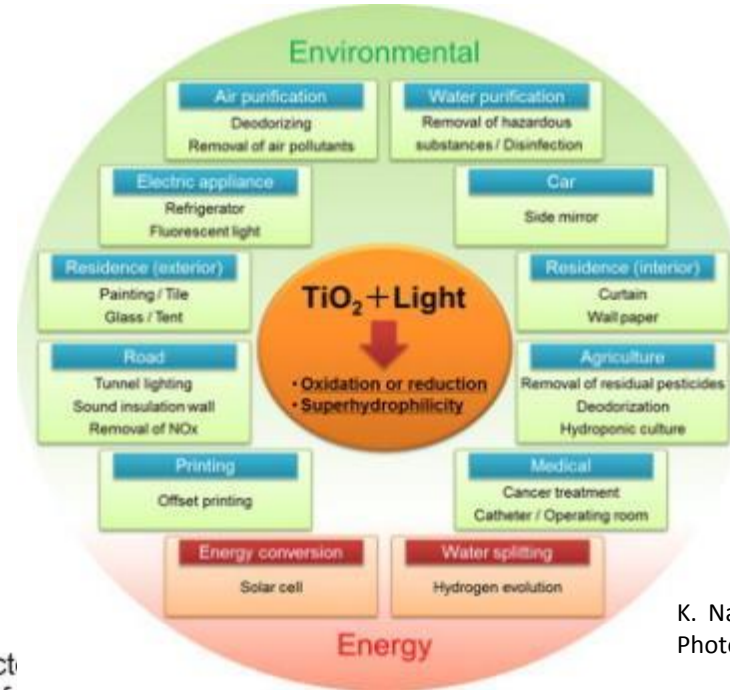
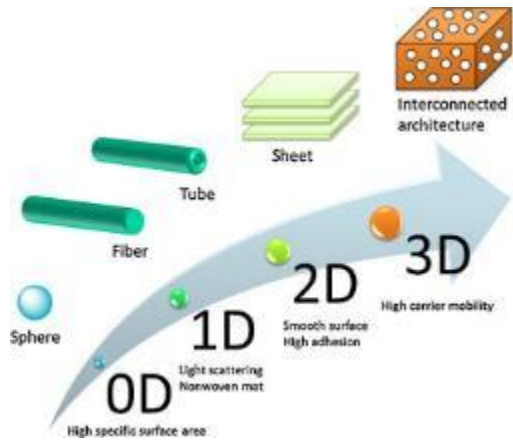
- Ability to reduce the concentration of contaminants from several-hundreds ppm ( $\text{mg}/\text{dm}^3$ ) to less than a few ppb ( $\mu\text{g}/\text{dm}^3$ )



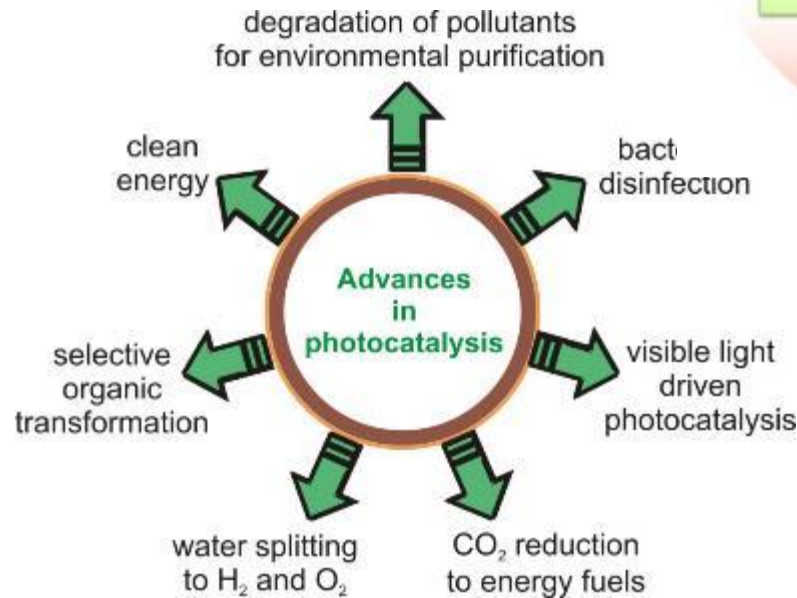
- biologically toxic or non-degradable materials such as aromatic, pesticides, petroleum etc.
- high concentrated (to increase /BOD/COD/ - biodegradability)
- volatile organic compounds in wastewater
- to treat effluent of secondary treated wastewater - **tertiary treatment**



# Recent advances in photocatalysis

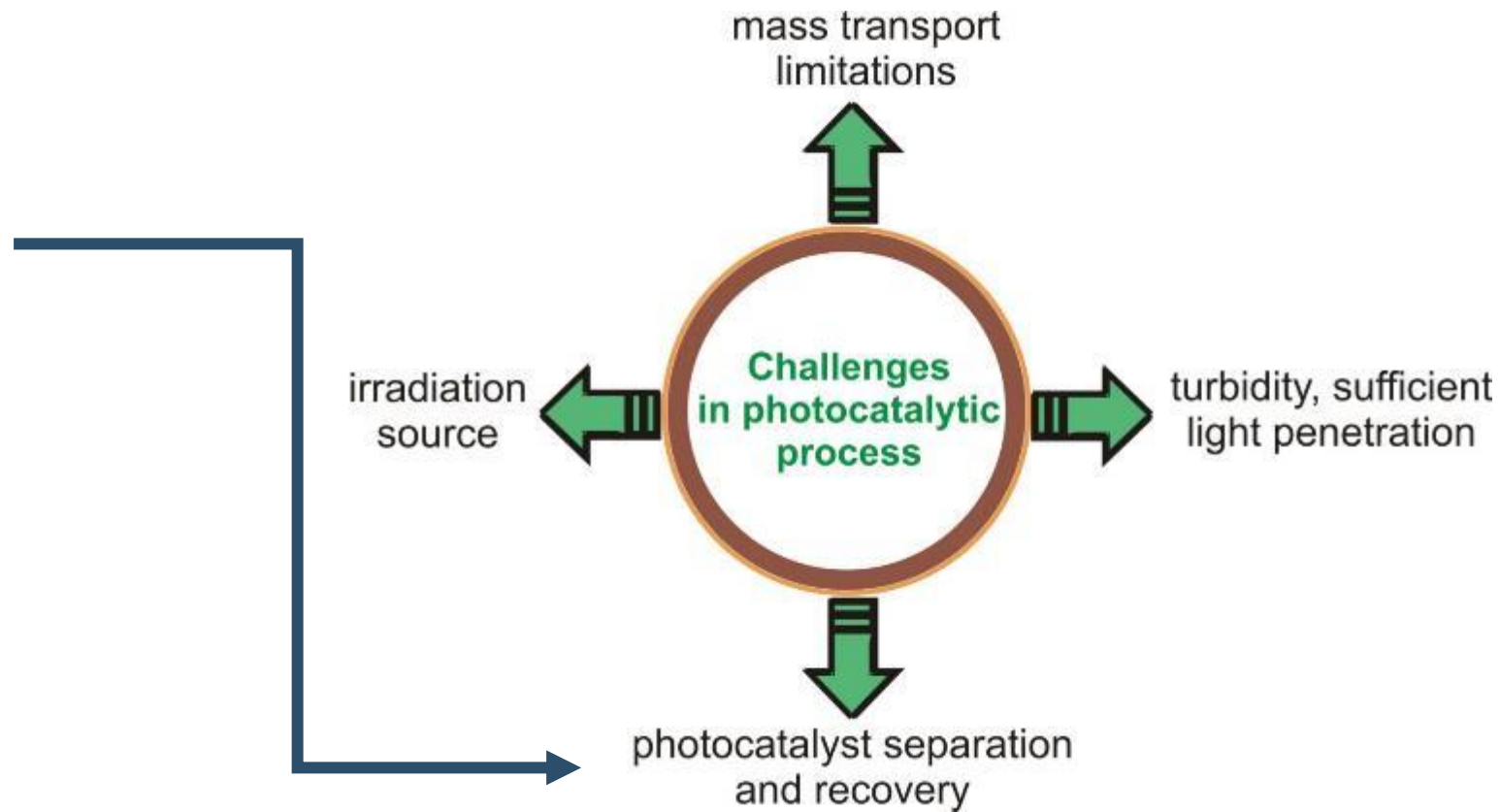


K. Nakata, A. Fujishima, J. Photochem. Photobiol. C: Photochem. Rev., 13 (2012) 169-189

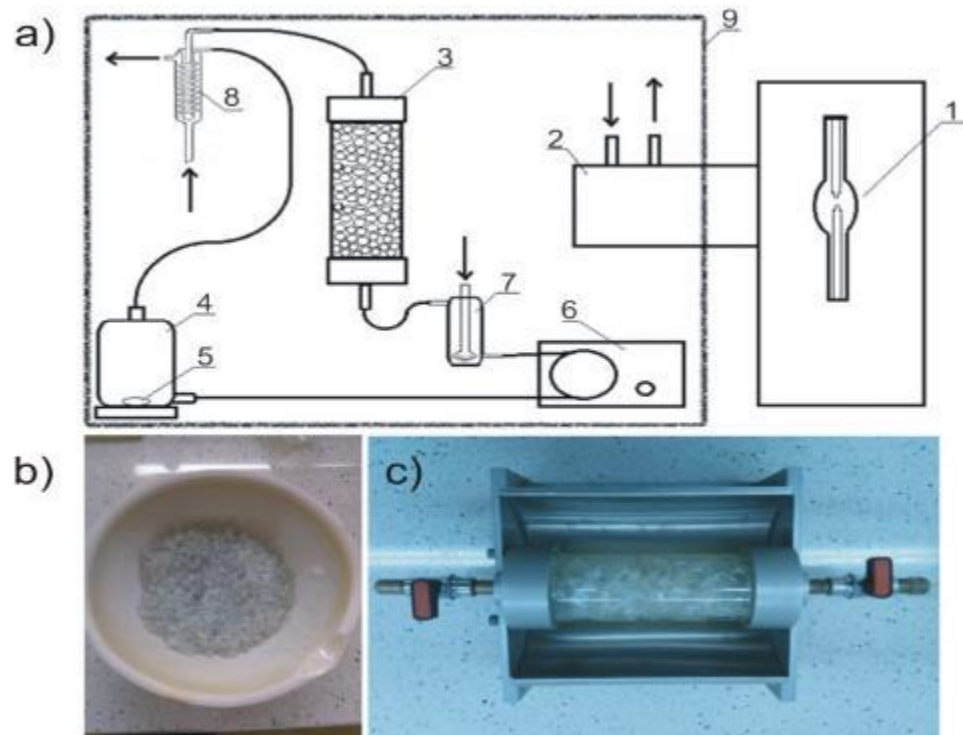


- development of a new light harvesting assemblies
- elucidation charge transfer processes
- improvement of hydrogen generation efficiency

# Technical challenges with large scale utilization of $\text{TiO}_2$ -based photocatalysis

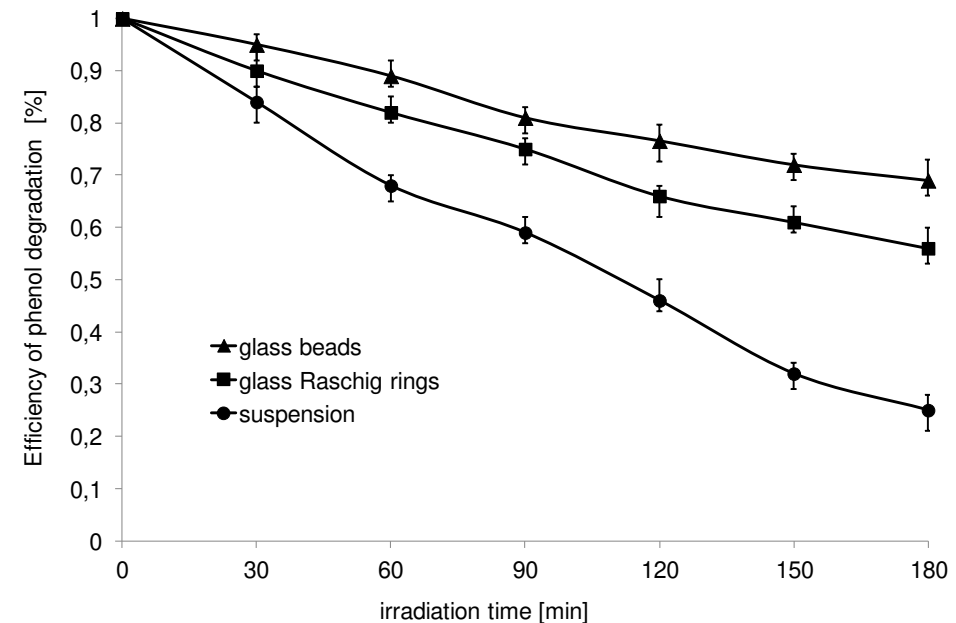


# Immobilization of photocatalyst nanoparticles on solid substrate



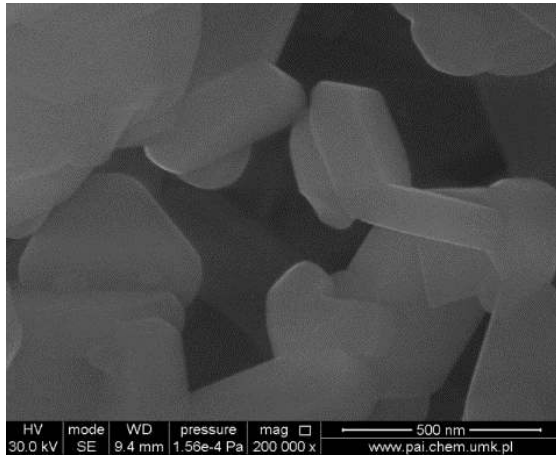
**a)** Experimental setup: 1-2) Irradiation source: UV-Vis, light flux 150 W/m<sup>2</sup>, 3) photoreactor with parabolic mirror, 4) storage tank, 5) magnetic stirrer, 6) peristaltic pump, 7) bubbling, 8) cooling water, **b)** glass beads (5 mm diameter); **c)** photoreactor filled with Raschig rings.

Photoreactor, made of a cylindrical quartz tube (i.d. 45 mm, length 130 mm) filled with Pt/I-TiO<sub>2</sub>-coated glass beads or Raschig rings and positioned over an aluminum parabolic mirror. 0.5 dm<sup>3</sup> of phenol solution (0.2 mmol/dm<sup>3</sup>) was pumped in a loop with a flow rate of 5 cm<sup>3</sup>/min, λ > 420 nm, 150W xenon lamp (flux=15 mW·cm<sup>-2</sup>)

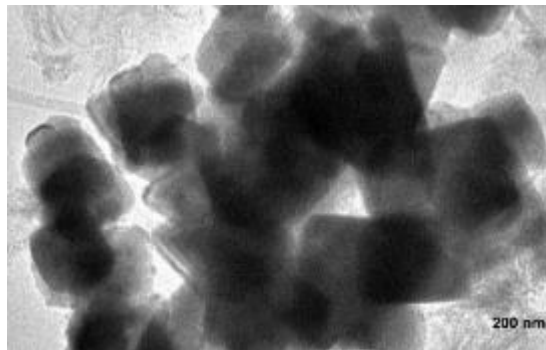


Efficiency of phenol degradation in fixed bed photoreactor with Pt/I-TiO<sub>2</sub> coating on glass Raschig rings, glass beads and in the slurry system.

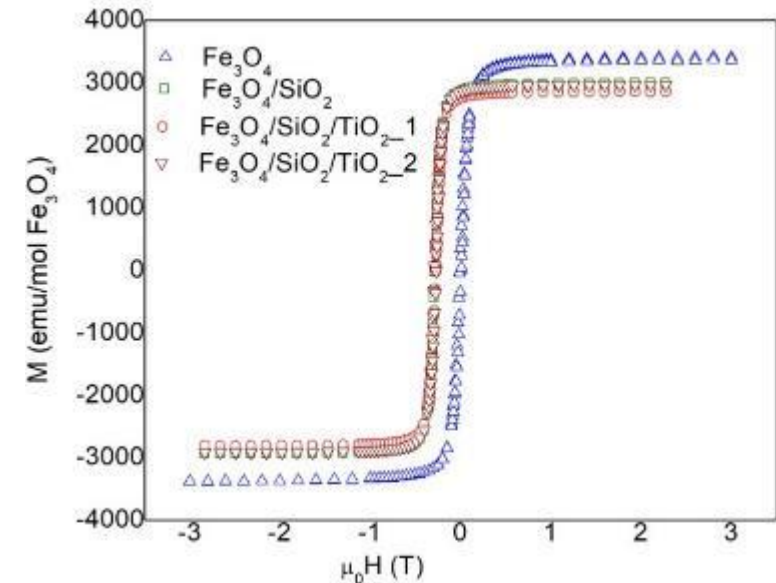
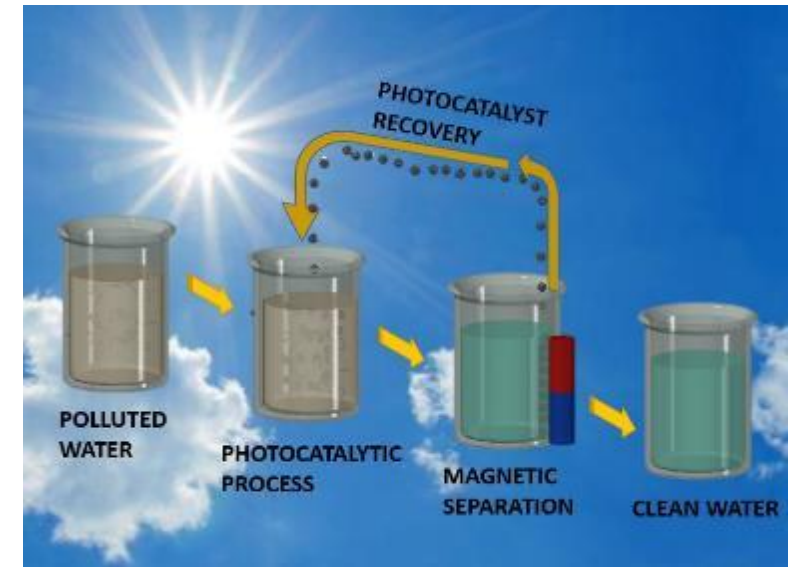
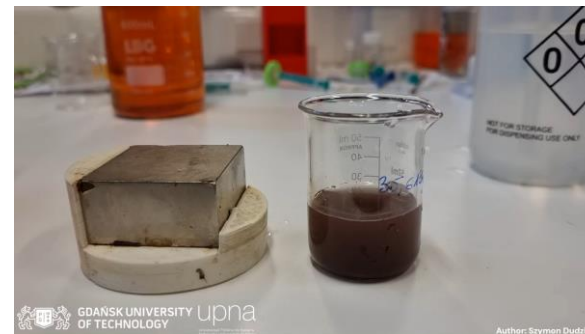
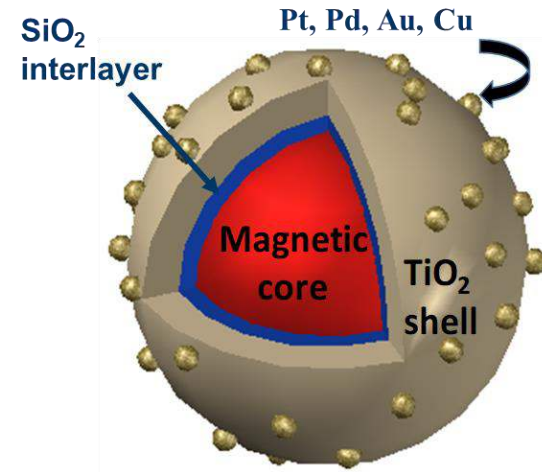
# Magnetic photocatalysts



$\text{BaFe}_{12}\text{O}_{19}$  as a magnetic core

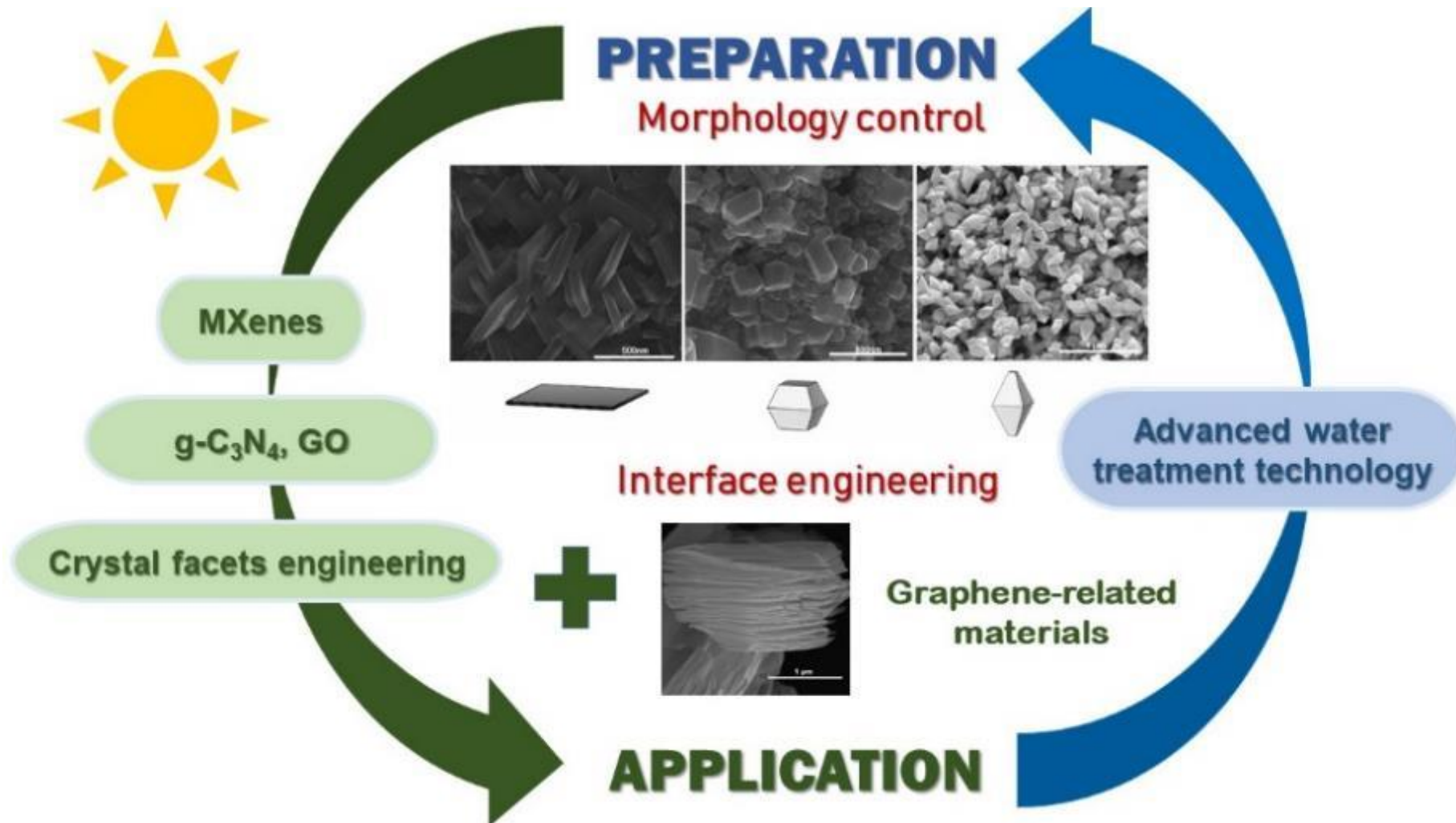


$\text{Fe}_3\text{O}_4$  as a magnetic core



Magnetic hysteresis loops for  $\text{Fe}_3\text{O}_4$  particles and  $\text{Fe}_3\text{O}_4/\text{SiO}_2/\text{TiO}_2$  nanocomposites

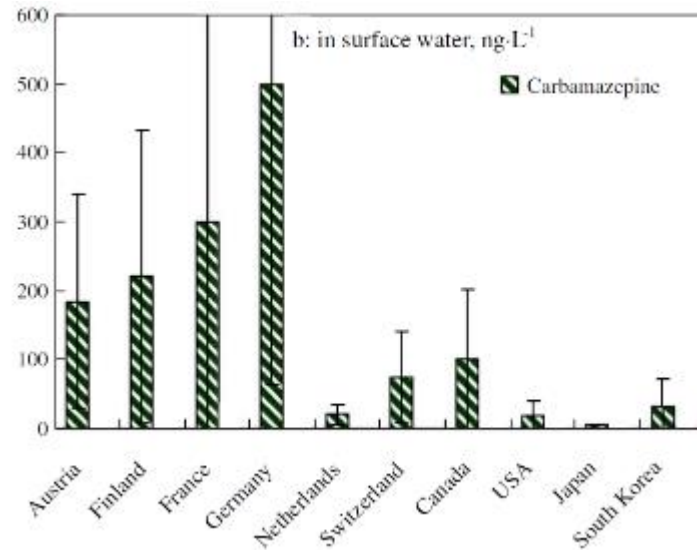
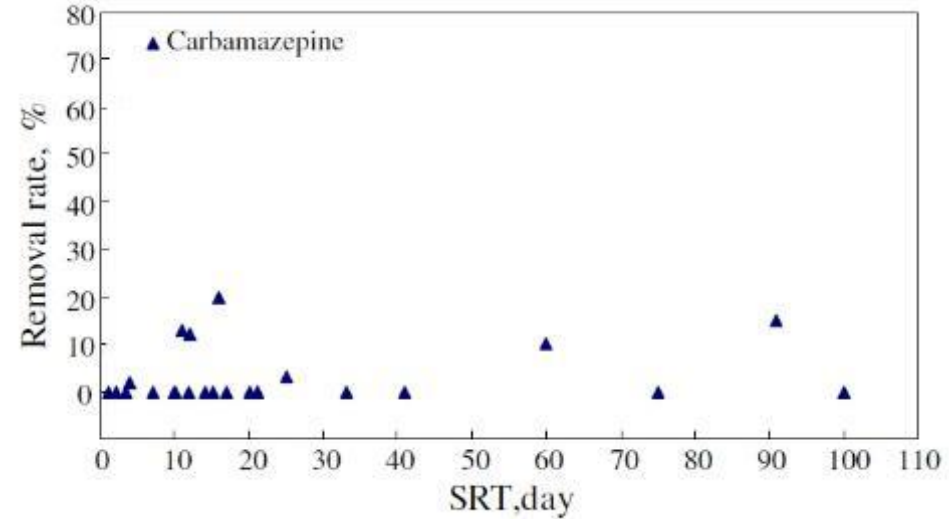
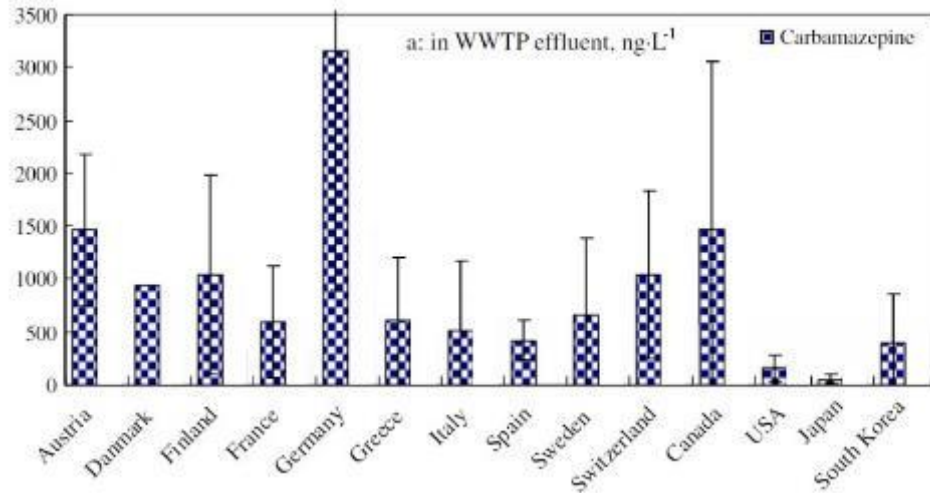
# Experimental design



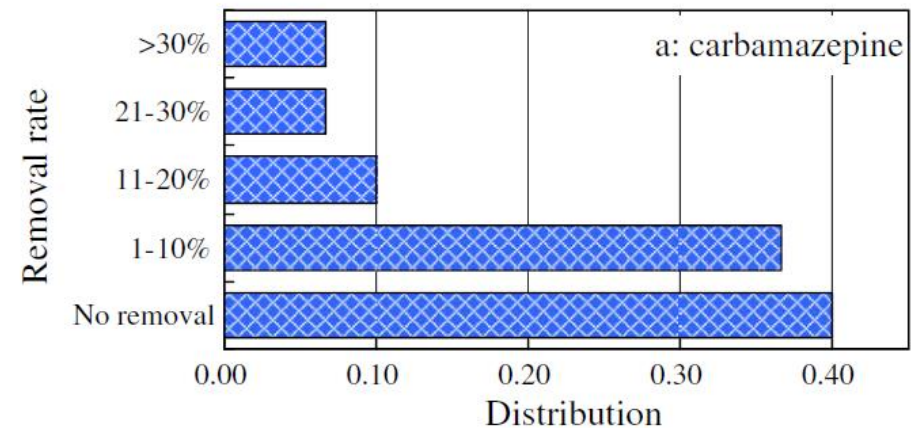


# Carbamazepine

- Carbamazepine - dibenzazepine derivative with antiepileptic and psychotropic activity, also well established in treatment of severe pain syndromes associated with neurological disorders, such as trigeminal neuralgia.



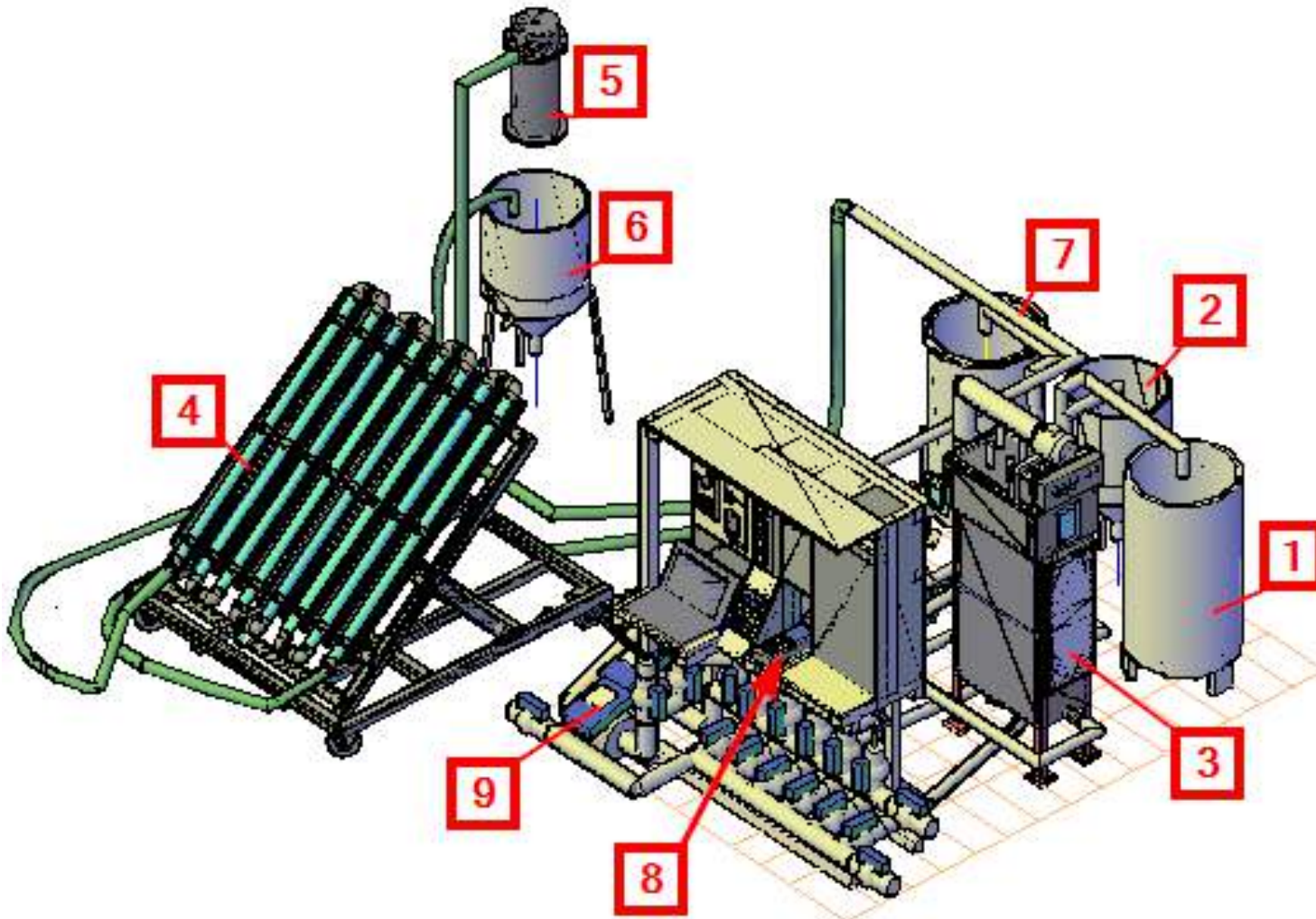
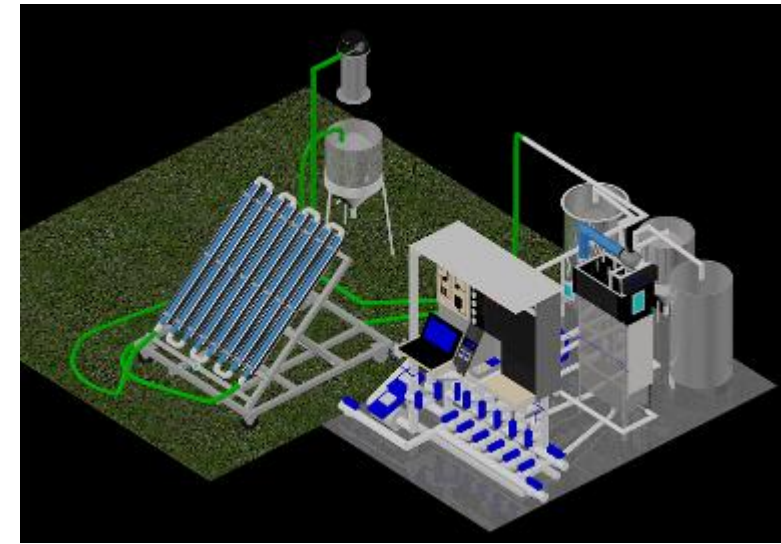
- Carbamazepine shows **low sorption** properties and **high persistence** to biodegradation



# Photocatalytic system for degradation of emerging contaminants in water



# Photocatalytic treatment system



1. Coagulation module
2. Suspended photocatalyst
3. Photoreactor 2 (ALPR)
4. Photoreactor (NLPR)
5. Hydrocyclone
6. Tank
7. Photocatalyst separation unit
8. Control panel
9. Pump

# Floating laboratory PHOTON

PHOTON lab is adapted to marine research and analytical technology



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AdvIQwater - Improving quality of BSR waters by advanced treatment processes