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Removal of Perfluorinated Compounds from water With Activated Carbon and Redox Treatments

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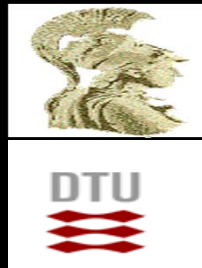
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INTRODUCTION

Perfluorinated Compounds (PFCs) are persistent micropollutants that have been detected in various environmental and biological matrices worldwide. Monitoring studies in Sewage Treatment Plants (STPs) have shown that these compounds are not significantly removed during conventional wastewater treatment. During the last years, scientific research has focused on practices that can reduce micropollutants' concentration in wastewater effluents. However, there is limited data about the removal of PFCs with Advanced Oxidation Processes (AOPs) and Activated Carbon (AC), while no data are available about their removal with reductive treatments.

The aim of this work was to investigate the removal of 6 PFCs (C5, C8 to C11 carboxylic acids and C8 sulfonic acid) in water by i) activated carbon (Powdered Activated Carbon; PAC, Granular Activated Carbon; GAC), ii) advanced oxidation processes such as: UV/H₂O₂, UV/S₂O₈²⁻ and iii) reductive treatments based on nano Zero Valent Iron (nZVI).

Sorption on Activated carbon

Preparation of AC

- Both GAC and PAC type activated carbon was soaked in pure water for 24 h to remove the impurities.
- Then dried in an oven at 105 °C for 48 h.
- Afterwards, PAC was crushed by a mortar, screened and stored in a desiccator.

Experiments

- Initially, the equilibrium time was estimated for each target compound using each type of AC.
- Additional batch sorption experiments were performed with each type of AC (see Table 1) and Freundlich constants (K_F) values were estimated.
- Last, the influences of solution pH and cations were investigated (see Table 1).

Table 1. Description of sorption experiments (all experiments in triplicate).

Types	PFCs (mg L ⁻¹)	pH	Na ⁺ / Ca ²⁺ (mM)
• Powder Activated Carbon	0.5	6	-
		7	1
		7	10
• Granular Activated Carbon	0.5	7	100
		8	-

Results

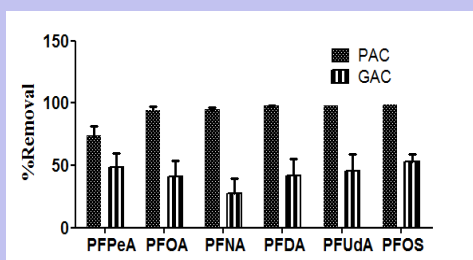


Figure 1. Removal of PFCs using different types of activated carbon (experimental conditions: pH=7)

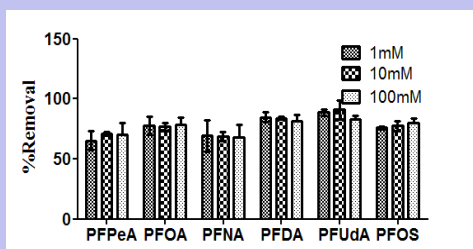


Figure 2. Effect of Ca²⁺ on the removal of PFCs using GAC.

Advanced Oxidation Processes

Experiments

- The experiments were performed in a quasi-collimated beam apparatus (Figure 3).
- Low pressure lamps were utilized.
- Two oxidant doses were investigated for each oxidant (see Table 2).
- Samples were taken at predetermined time intervals.

Table 2. Experimental set up of AOPs experiments.

Treatments	PFCs (mg L ⁻¹)	Oxidant (mg L ⁻¹)	Irradiation time (hours)
Control	0.2	-	0
UV	0.2	-	12
UV/S ₂ O ₈ ²⁻	0.2	10	12
UV/S ₂ O ₈ ²⁻	0.2	100	12
UV	0.2	-	24
UV/H ₂ O ₂	0.2	20	24
UV/H ₂ O ₂	0.2	200	24



Figure 3. The apparatus used in this study.

CONCLUSIONS

Activated Carbon

- Sorption equilibrium was reached within 4 and 24 hours using PAC and GAC, respectively.
- Higher removal for all PFCs was observed for PAC than GAC (Figure 1).
- Sorption of was not affected at pH values tested (6≤pH≤8).
- No significant effect on PFCs sorption was observed when different Ca²⁺ and Na⁺ concentrations were used for both types of AC. Figure 2 depicts the results from the Ca²⁺ /GAC experiments.

Advanced Oxidation Processes

- No significant PFCs removal was observed for the experimental conditions used (data not shown).

Nano Zero-Valent-Iron

- PFCs were only removed by nZVI modified with Mg-aminoclay.
- Higher PFCs removal was observed at pH=3 comparing to pH=5 and pH=7.
- The removal of PFCs increased with decrease of temperature (Figure 4).
- Higher removal was observed with increasing concentration of nZVI from 10 to 100 mg L⁻¹, while no significant increase was observed from 100 to 1000 mg L⁻¹ (except PFOA; Figure 5).

Reduction with nano Zero-Valent-Iron

Experiments

- Batch experiments were performed for each PFC using three types of nZVI (see Table 3).
- Samples were taken at predetermined treatment time (1, 3, 24 h).
- Additionally, the influence of nZVI concentration, solution pH and temperature were studied (see Table 3).
- With every test, samples with no Fe⁰ were run as control.

Table 3. Experimental set up of nZVI experiments (all experiments in triplicate).

Types	PFCs (mg L ⁻¹)	nanoZVI (mg L ⁻¹)	pH	T (°C)
• Commercial nZVI	0.2	10, 100, 1000	3	20
			3	55
• Freshly synthesized nZVI	0.2	10, 100, 1000	5	20
			5	55
• Freshly synthesized nZVI modified with Mg-aminoclay	0.2	10, 100, 1000	7	20
			7	55

Results

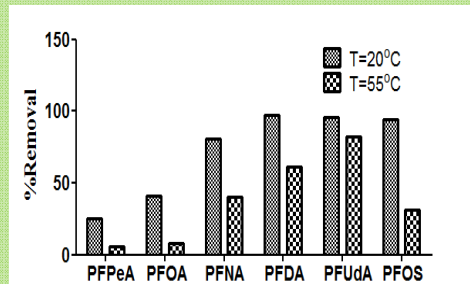


Figure 4. Effect of temperature on the removal of PFCs using chemically synthesized nZVI modified with Mg-aminoclay (experimental conditions: pH=3, 1000 mg L⁻¹ nZVI)

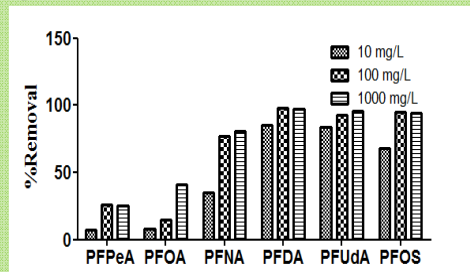


Figure 5. Effect of different concentrations of chemically synthesized nZVI modified with Mg-aminoclay on removal of PFCs (experimental conditions: pH=3, T=20°C)

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