# Removal of pharmaceuticals by oxidative treatment of toilet effluents from hospital wards

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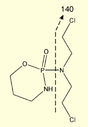
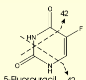
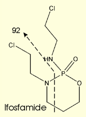

Cyclophosphamide


5-Fluorouracil

## Introduction

Hospital waste water still represents the main pathway for the input of hazardous pharmaceuticals into the aquatic environment. This especially applies to high effective drugs, applied to combat life threatening diseases, such as cancer or infections, which are predominantly administered during patient treatment. Besides other strategies for minimisation of drug input, e.g. collecting and disposal of patient excreta, purification of the total hospital waste water or special treatment of effluents from sewage treatment plants (STP), the treatment of effluents from toilets on hospital wards offer a comparatively simple and effective alternative. The object of the two step research project is to develop procedures for elimination of human medicines and their active metabolites in toilet effluents from hospital wards.

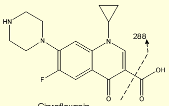

Ifosfamide

## Method

For optimisation the effectiveness of control of advanced oxidation processes (AOP) in lavatory and hospital waste water, it was necessary to develop a suitable multi-method for structurally very different compounds with a simple sample preparation. After filtration through a 0.45 µm cellulose acetate filter, the samples could be analysed directly by LC-MS/MS.

In the first stage laboratory scale methods for destruction of cytotoxic and antimicrobial drugs using advanced oxidation processes (AOPs) were developed. Main parameters of the process, such as type and concentration of the oxidant ($H_2O_2$, $O_3$), intensity and type of UV-light as well as the residence time have been optimised using spiked samples and a laboratory scale reactor.

The oxidation experiments were carried out with a 1 L laboratory reactor (fig. 1) equipped with a peristaltic pump, a 5 L container, a thermostat and a mercury low or mercury medium pressure lamp (Heraeus).


Ciprofloxacin

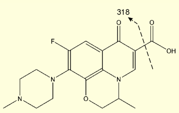
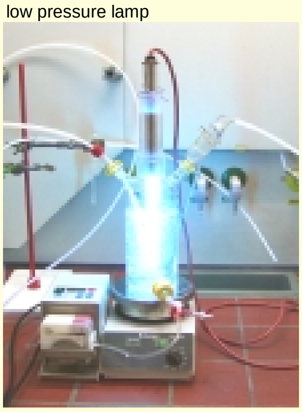

Ofloxacin

**Figure 1** Reactor equipped with Hg-low pressure lamp



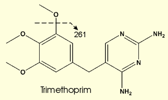
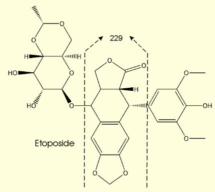

Trimethoprim

**Table 1** Half-time of cyclophosphamide (CP), compound reduction and reduction of mutagenicity by different AOP procedures

| | $t_{½}$ CP [min L$^{-1}$] | Compound reduction > 99 % [min L$^{-1}$] | Mutagenicity (umuC) [GL] | [reduction %] |
|---|---|---|---|---|
| Hg-LP (15W/L) + 1 g/L $H_2O_2$ | 3.9 | 15 | GL 6 | 99.2 % |
| Hg-MP (2100 W/L) + 1 g/L $H_2O_2$ | 0.4 | 1.7 | GL <1.5 | 99.8 % |
| $O_3$ (25 mg/min L$^{-1}$) | 2.6 | 11 | GL <1.5 | 99.8 % |

Hg-LP: mercury low pressure lamp, Hg-MP: mercury medium pressure lamp
GL: Dilution factor of umuC-test, untreated waste water: GL 768


Etoposide

## Conclusions

We developed and optimised a fast and effective oxidation procedure to remove pharmaceuticals in hospital waste water using advanced oxidation processes. Mercury low and medium pressure lamps in combination with hydrogen peroxide and/or ozone are possible. For the introduction of this new technology in hospitals, the different procedures has to be optimised for their economic efficiency.

## Results

The efficiency of the treatment procedures (> 99 %) was controlled by substance specific analysis using HPLC-MS/MS. Additional ecotoxicological tests also showed the reduction of the genotoxical potential (> 95 %) of the treated effluents (tab 1).

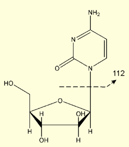
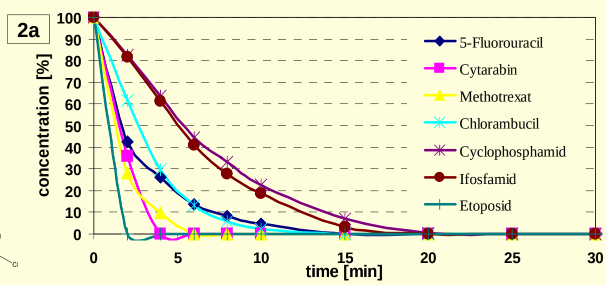
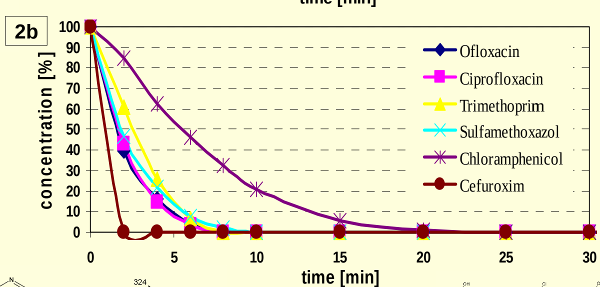
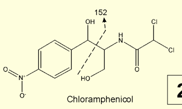

Cytarabine

**Figure 2** Degradation curves of antineoplastic agents (a) and antibiotics (b) by AOP with Hg-low pressure lamp at 40°C and 1 g/L $H_2O_2$.

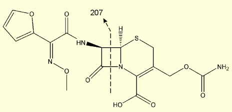




Chloramphenicol

## Outlook

Main task of the subsequent technical project will be the scale-up of the optimised procedure and the construction and test of a pilot plant in a hospital (fig. 3).


Cefuroxime

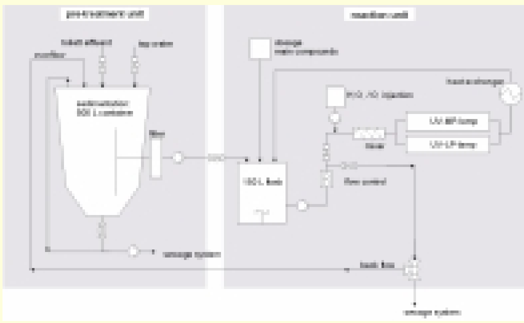
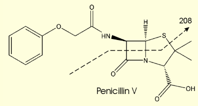
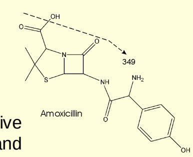


**Figure 3** Projected pilot plant


Penicillin V

Finally we will compare the the economical efficiency of the different procedures with the pilot plant for their application in hospitals.


Amoxicillin

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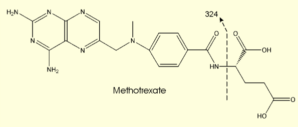
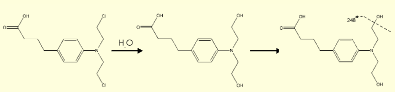
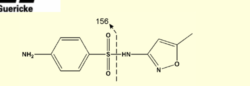
Otto von Guericke


Methotrexate


Chlorambucil dihydroxy derivate


Sulfamethoxazole