Pharmaceuticals in the environment

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ENVIRONMENTAL BIOTECHNOLOGY DEPARTMENT

- Environmental Biotechnology Department of the Silesian University of Technology, is one of the leading Polish research centers in the field of environmental biotechnology with wide contacts in whole Europe with research centers involved in environmental engineering.

- Since 2000 the EBD is involved in the research on occurrence and fate of pharmaceuticals and personal care products (PPCPs) in the environment.
FATE OF PPCPs IN THE ENVIRONMENT

- Human medicine
  - Excreta
  - Wastewater
  - WWTPs
- Veterinary medicine
  - Excreta
  - Manure
- Aquiculture
- Wastewater from drugs production
- Surface water
- Groundwater
- Drinking water
- Landfill
- Landfill leachates
- Infiltration
- Waste

PPCPs

„Assessment of Technologies for the Removal of Pharmaceuticals and Personal Care Products in Sewage and Drinking Water Facilities to Improve the Indirect Potable Water Reuse”

Participants of POSEIDON:

- Federal Institute of Hydrology, Germany
- Swiss Federal Institute of Environmental Science and Technology (EAWAG), Switzerland
- Tampere University of Technology, Finland
- Vienna University of Technology, Austria
- University of Santiago de Compostela, Spain
- Silesian University of Technology, Poland
- Ecotoxicology GmbH ECT, Germany
- CIRSEE, Suez Environment, France

http://poseidon.bafg.de/servlet/is/2890/
POSEIDON was focused on the assessment of technologies for the removal of PPCPs in municipal wastewater and in drinking water facilities. To achieve the objectives of the project, POSEIDON was organised in seven Workpackages (WP). EBD was involved in WP-1. WP-1 was focused on improvement of conventional wastewater treatment and more advanced technologies like membrane devices, SBR-reactors, chemical oxidation of organic pollutants (best available technology), which are already used in most European countries, for the removal of selected PPCPs.

http://poseidon.bafg.de/servlet/is/2890/

- In the frame of POSEIDON project, EBD performed the monitoring raw wastewater from one Polish municipal wastewater treatment plant (WWTP Zabrze „Śródmieście”) in terms of PPCPs content.
- The residues of 30 pharmaceutics belonging to particular drugs classes like contrast media, antibiotics, lipids regulators, antiphlogistics, psychiatric and antiepileptic agents, drug’s metabolites and 2 musk compounds have been investigated.
- The investigation showed occurrence 20 from 32 selected compounds above their limit of detection.

- Iopromide, compound belonging to contrast media, was noticed at the highest concentration (27.0 μg/L)
- Other drugs like iopamidol, iomeprol, diatrizoat, iohexol, sulfomethoxazole, carbamazepine, ibuprofen, ibuprofen-OH, naproxen, diclofenac, bezafibrate, ketoprofen and musk compound – galaxolide were detected at maximum concentration between 1.0 μg/L (bezafibrate) and 13.0 μg/L (iomeprol)
- The acidic compounds such as gemfibrozil and indomethacin were determined above their limit of detection, with concentration up to 0.22 μg/L and 0.42 μg/L, respectively.
During the POSEIDON project, the application of SBR-reactors (operated in various conditions) for removal PPCPs from wastewater has been investigated.

- Anti-inflammatory drug, naproxen, was most efficiently removed from wastewater using SBR reactors, regardless of their operating conditions.
- Ibuprofen, ibuprofen-OH, iopromide and bezafibrate were more efficiently removed from wastewater at $T = 20^\circ C$ (70 - 97%).
- Anti-epileptic drug, carbamazepine, was not removed from wastewater using SBR reactors.

„Scheme to provide training and assistance for research players for the assessment of the fate and removal of pharmaceuticals and estrogenic compounds released into the environment”

Participants of TRITON:

- University of Santiago de Compostela, Spain
- Johannes Gutenberg University – Mainz, Germany
- Tampere University of Technology, Finland
- Federal Institute of Hydrology, Germany
- Silesian University of Technology, Poland
- Vienna University of Technology, Austria

http://www.ist-world.org/

- The TRITON project related to EU funded project, which studies the multi-barrier approach to control discharge of PPCPs into the aquatic environment.
- The project was meant to implement the results obtained by existing EU project by providing training for the research players in this research consortia including authorities and end-users.
- The training was carried out by arranging workshops and seminars as well as by Internet based distant learning methods.
- The areas of training cover the analysis of PPCPs in the environment, environmental risk reduction technologies, and environmental risk assessment and management.

http://www.ist-world.org/

Knowledge and Need Assessment on Pharmaceutical Products in Environmental Waters

Participants of KNAPPE:

- Armines – Ales, France
- University of Portsmouth, UK
- Consejo Superior de Investigationes Cientificas, Spain
- Bureau de Recherche Geologique Miniere, France
- University of York, UK
- Federal Institute of Hydrology, Germany
- Agricultural and Environmental Engineering Research Institute, France
- Ecologic Institute for European and International Environmental Policy, France
- Silesian University of Technology, Poland

http://www.knappe-eu.org/
EU PROJECT - „KNAPPE” (2007 – 2008)

The aim of the KNAPPE project was to identify the relevant priority actions to be taken in order to reduce presence, impacts and risk of Pharmaceutical Products (PPs) in environmental waters. To achieve the objectives of the project, KNAPPE was organised in six Workpackages (WP). EBD was involved in WP-2, the objective of which was to put emphasis the causes and effects of deficient wastewater treatment efficiencies and open the discussion of the future evolution to limit them.

KNAPPE General organisation

EUROPEAN COMMISSION
DG RESEARCH

CO-ORDINATOR
General co-ordination, management, communication

SCIENTIFIC COUNCIL
(Chair persons of the different work packages)

EXECUTIVE COMMITTEE
WP leader + external experts of the pharmaceutical topic

Work Package 1
Towards indicators for contamination with pharmaceuticals

Work Package 2
Towards best practices for lowering PP's contamination in the aquatic environment

Work Package 3
Develop cornerstones of an EU prevention action

Work Package 4
Impacts/effects of PP

Work Package 5
Eco-Pharmacostewardship and vigilance

Work Package 6
Communication, results dissemination and proposition of priority actions

Whole community: Public, association, third countries, ...

http://www.knappe-eu.org/
During the whole duration of KNAPPE project, the strategy of communication has been focused on several audiences and target groups: industrial (pharmaceutical companies), medical (doctor, pharmacist, hospital), social (patient), environmental (water manager, water producer, scientists) and regulatory spheres.

An extensive data compilation on the environmental occurrence of PPs was created, including 58400 measurements of 178 pharmaceutical products in 22 countries in WWTP influents, WWTP effluents, surface water, groundwater, bank filtrate, marine water and drinking water.
EUD research were to:

- Identify groups of human pharmaceuticals according to their removal rates by current biological sewage treatments and try to establish links with their physico-chemical properties
- Assessment of the concentrations of pharmaceuticals in sewage sludge and hence their potential contribution to the pollution of environment for sludge reuse or disposal
- Possibilities to improve the existing technologies
- Suggestion of different strategies for PPs treatment with identification of future requirements (suggestions for treatment at the source, even restrictions in use).

In order to sum up, the following statements can be formulated:

- PPs belonging the to same therapeutic groups do not show the similar removal rate. It is caused by the fact, that they possess the different chemical structure and/or differ in issue/organs action.

- Behavior of the PPs in sewage sludge is the issue, which demands more investigations. In most cases there are some single records, which give very general overview of the sorption and desorption processes of PPs.

http://www.knappe-eu.org/
EU PROJECT - „KNAAPPE” (2007 – 2008)

- According to the available data concerning wastewater treatment it can be stated, that WWTPs (e.g. conventional activated sludge processes, membrane assisted bioreactors) configuration is not a factor, which have the highest impact on the PPs removal. It is rather connected with parameters, such as sludge retention time (SRT) and hydraulic retention time (HRT) which seem to be the crucial parameters and the visible correlation with the PPs removal rates can be observed.

- Source control and source separation could be implemented in order to reduce or minimize the introduction of pharmaceutical compounds to the environment.

http://www.knappe-eu.org/
PROJECT „Antibiotic resistance transfer among activated sludge bacteria”

This project was financially supported by Polish Ministry of Science and Higher Education, grant no. NN 523493134.

Participants of the project:
- Silesian University of Technology
- Gdańsk University of Technology

Aim of the project:
The aim of the project was to estimate the influence of particular antibiotics on the spreading of bacteria resistant to these antibiotics. Estimation of biodiversity changes in WWTP activated sludge under the exposition on particular types of antibiotics was also undertaken.
The activities of the project were focused on:

- The detection and determination of antibiotics in raw and treated wastewater and activated sludge samples from different WWTPs, located in two distinct regions (WWTP „Zabrze Śródmieście”, South Poland; WWTP „Gdańsk Wschód”, Northern Poland)

- Antibiotic resistance detection in pure bacteria strains and activated sludge from two WWTPs using molecular methods (PCR/polymerase chain reaction and FISH/fluorescent in situ hybridization)

- The investigation of the impact of three different disinfection methods on antibiotic resistant bacteria in selected WWTPs.
Antibiotic resistance transfer among activated sludge bacteria

The main conclusions from the project:

- The occurrence of clarithromycin, erythromycin, sulfamethoxazole (and its derivative), trimethoprim in wastewater and sludge sample was evidenced in this study.
- Clarithromycin, sulfamethoxazole and trimethoprim were detected in all analyzed wastewater samples. The maximum concentrations of these substances equaled to 2008.0 ng/L, 1847.5 ng/L and 895.0 ng/L, respectively.
The main conclusions from the project:

- FISH is an useful method for such antibiotic resistance detection, as clarithromicin, but in case of genes on movable elements (plasmids, transposons) it is difficult to perform such analysis.

- PCR is an useful method for antibiotic resistance genes detection located on movable elements. Multiplex PCR seems to be the most suitable tool for several antibiotic resistance genes detection in the same time in one environmental sample.
The main conclusions from the project:

- It was stated that wastewater treatment processes can select antibiotic resistance bacteria, so sewage disinfection is recommended. Nevertheless it should be mentioned that the disinfection process itself can also promote antibiotic resistance transfer.
The other projects

In the EBD, the other projects concerning the problem of removing micropollutants from the environment were implemented:


- Removal of refractory compounds belonging to the group of pharmaceuticals from aqueous solutions and urine by means of iron salts (II) and other catalysts, Polish Ministry of Science and Higher Education, 2006 – 2009, no. 1T09D 085 4
The other projects

In the EBD, the other projects concerning the problem of removing micropollutants from the environment were implemented:


GENERAL CONCLUSION

In Poland, over the past decade, the consumption pattern of antibacterial agents has been changed. The raw wastewater monitoring performed in the year 2002 revealed an occurrence only sulfamethoxazole as a substance from the group of antimicrobial agents. The investigation performed in the year 2009 showed the occurrence sulfamethoxazole and the other antibiotics, e.g. roxithromycin, erithromycin and clarithromycin (substances belonging to the group of macrolide antibiotics).
GENERAL CONCLUSION

- When calculating the removal degree of sulfamethoxazole, the concentration of its main derivative (N-acetyl sulfamethoxazole) should be also taken into account, because in the conditions of biological treatment, it is often the case that re-conversion of the metabolite into the primary compound occurs (regardless of the temperature of the process).

- During biological processes, most of pharmaceuticals is more efficiently removed at higher temperatures. For example, the average removal of clarithromycin at $T = 10^\circ C$ was equal to 47% and at $T = 20^\circ C$ was equal to 66%.
GENERAL CONCLUSION

- WWTPs were confirmed to be an antibiotic resistant genes reservoir by PCR and FISH analysis, as well as the standard microbiological methods.
- According to the available data, the municipal WWTPs are not able to guarantee a complete elimination of pharmaceuticals. However, there are some possibilities of the enhancing drugs removal at the existing facilities. Combination of advanced oxidation processes with biological processes increases the removal efficiency of drugs from sewage. For example, the removal of diclofenac from the wastewater after 2 min. of UV/H2O2 process was equal to 100%. After the same time, the removal of naproxen and ibuprofen equaled to 85% and 80%, respectively.
THANK YOU

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