



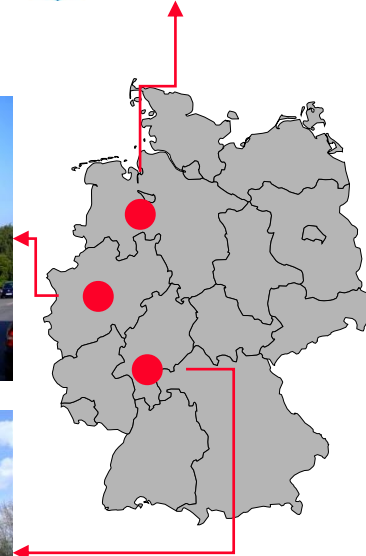
# | WATER CENTRE

CONSULTING – RESEARCH – TRAINING



## ■ IWW in figures (2014)

- 100 scientists, engineers, economists and technicians
- Sales revenues 8 Mio. EUR
  - 35 % Research, 65 % Consulting
- Customers
  - Water supply ca. 50 %
  - Government (national/regional/local) ca. 20 %
  - Industry ca. 25 %



## ■ Regional branches

Mülheim an der Ruhr, North-Rhine Westphalia

IWW Rhein-Main: Biebesheim, Hesse

IWW Nord: Diepholz, Lower Saxony

„Our strength lies in  
interdisciplinary work “



# The use of bioassays for process optimization of Waste Water Treatment Plants

A. Simon, H. Bielak, E. Dopp

9<sup>th</sup> BioDetectors conference 2016, Lausanne, 14 -15 April, 2016



IWW RHEINISCH-WESTFÄLISCHES INSTITUT FÜR WASSER  
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Institut an der  
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ESSEN



# Introduction

- Pharmaceutical residues can enter the water cycle and can cause harm to the aquatic environment and to humans
- Advanced technologies on municipal wastewater treatment plants (WWTP) for elimination of micropollutants
- Most efficient advanced treatment technologies based on
  - adsorptive
  - oxidative processes

# Introduction

- Use of an effect-based approach to assess the combined toxicity of micropollutants in wastewater
- Project 1: Study of metabolite formation during the use of ozone in municipal wastewater treatment plants
- Project 2: Study of endocrine activities in ozone treated hospital wastewater
- Project 3: Investigation of the breakthrough of micropollutants at aged activated carbon filters

# Bioassays

## In vivo

Green algae (*Desmodesmus Subspicatus*)

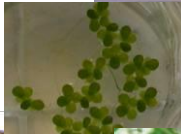
Duckweed (*Iemna minor*)

Water flea (*Daphnia magna*)

Draw snail (*Potamopyrgus antipodarum*)

Fish (*Danio rerio*)

Gloss worm (*Lumbriculus variegatus*)

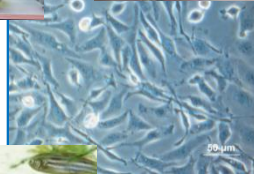


## In vitro

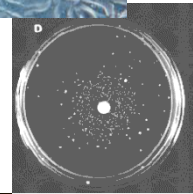
General cell damage (Cytotoxicity)



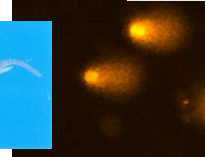
DNA damage (Genotoxicity)



Estrogenic effects (Estrogenicity)

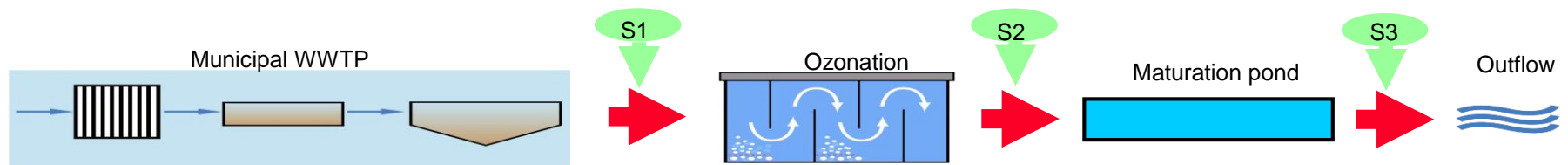


Inheritable DNA damage (Mutagenicity)



## Study of metabolite formation during the use of ozone in municipal wastewater treatment plants

### ozonation:





# Investigated municipal WWTP

## WWTP Bad Sassendorf (Lippeverband)

- 12,000 PE
- Post treatment dosing of ozone to the effluent of conventional biological treatment. Polishing pond.



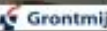
## WWTP Schwerte (Ruhrverband)

- 50,000 PE
- Consists of two separated lines. Ozone and/or powdered activated carbon are applied. Recirculation process can be operated.



## WWTP Duisburg-Vierlinden (Wirtschaftsbetriebe Duisburg AöR)

- 30,000 PE
- Two parallel lines have been installed to compare ozone dosage by diffuser or by injector. The outflow feeds into a fluidized bed reactor.



## Study of metabolite formation during the use of ozone in municipal wastewater treatment plants

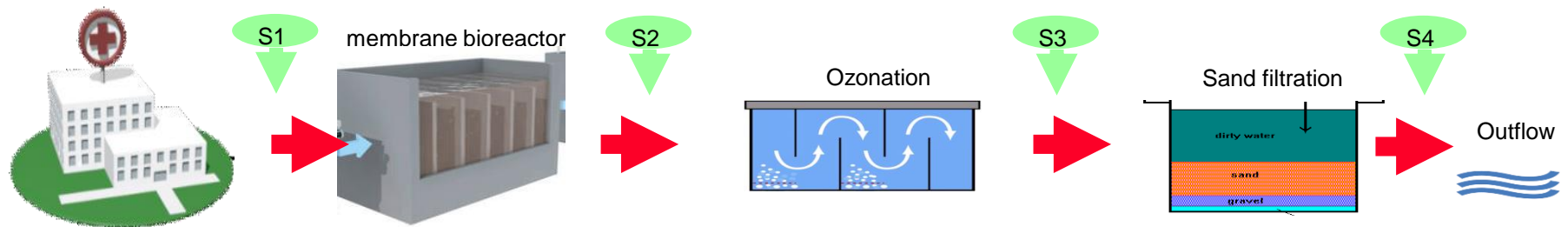
- reduced amount of micropollutants in the effluent of WWTP Schwerte due to the use of powdered activated carbon
- no detection of bromate and nitrosamines after ozonation
- up to 60 transformation products
- reduced estrogenic activity *in vivo* (potamopyrgus), *in vitro* only in extracted samples detectable. In general: reduction of estrogenicity after ozonation

## Study of metabolite formation during the use of ozone in municipal wastewater treatment plants

- increased toxicity for algae and sediment dwelling-worm after ozonation → Toxicity could be reduced after secondary clarification
- neither genotoxicity, nor mutagenicity observable
- not any toxicity for duckweed, daphnids, and zebra mussel

## Study of endocrine activities in ozone treated hospital wastewater

ozonation:



## Study of endocrine activities in ozone treated hospital wastewater

Application of different reporter-gene assays for the determination of estrogen and androgen active substances of ozone treated hospital wastewater.



Gehrmann, L.<sup>1</sup>, Bielak, H.<sup>2</sup>, Behr, M.<sup>3</sup>, Itzel, F.<sup>1</sup>, Lyko, S.<sup>4</sup>, Simon, A.<sup>2</sup>, Gotthard Kunze<sup>5</sup>, Dopp, E.<sup>2</sup>, Wagner, M.<sup>3</sup>, Tuerk, J.<sup>1</sup>

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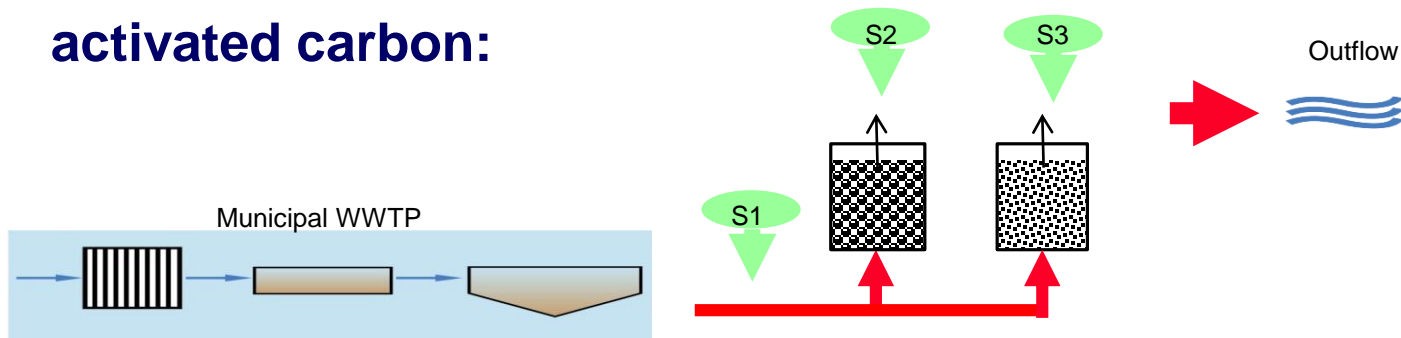
<sup>3</sup> Goethe University Frankfurt, Abteilung Aquatic Ecotoxicology, Frankfurt am Main, Germany



- Comparison of three bioassays: ER-CALUX, YES, and A-YES as well as AR-CALUX, YAS, and A-YAS and their antagonistic effects
- estrogenic and androgenic effects were removed efficiently
- anti-estrogenic and anti-androgenic activities were reduced partially

## Investigation of the breakthrough of micropollutants at aged activated carbon filters

activated carbon:



# Investigated municipal WWTP

## WWTP Rodenkirchen (Cologne Wastewater Company – StEB)

- 88,000 PE
- Development of adsorptive treatment after the conventional biological treatment.



## WWTP Gütersloh-Putzhagen (Stadt Gütersloh)

- up to 570,000 PE
- 3 activated carbon filters in the testing phase.

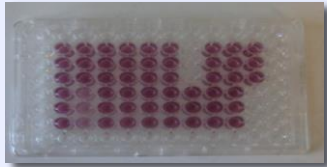
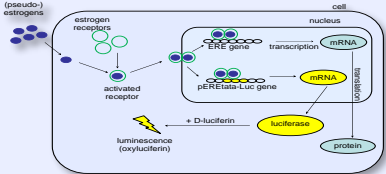
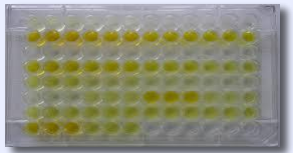
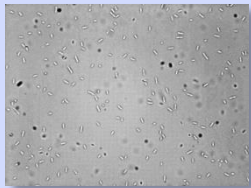
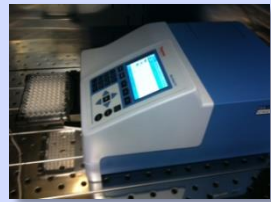

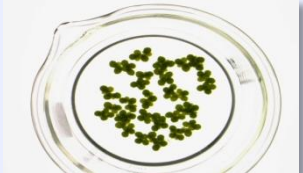




## WWTP Ober Lutter (AOL)

- up to 380,000 PE
- Up to 5 activated carbon filters.



# Project 3: Biotest battery

<p>Cellular level</p> <p>↓</p>	 <p>MTT-Assay</p>	 <p>ER-CALUX</p>	 <p>umuC-Assay</p>
<p>Decomposers</p> <p>↓</p>		<p>luminescent bacteria (acute and chronic)</p>	
<p>Primary producers</p> <p>↓</p>	 <p>Algae</p>		 <p>Lemna*</p>
<p>Primary consumers</p>		<p>Daphnids</p>	

\*Dependent on previous results with *D. subspicatus*



# Conclusions

- Biologically active substances as well as transformation products are detectable in water samples
- Micropollutants can be removed by both treatment steps (effectiveness depends on many factors):
  - Ozonation
  - Activated carbon filters
- Application of bioassays is useful for detection of toxicity (mixture toxicity)

# Conclusions

- Bioassays enable a monitoring of the proposed environmental quality standard for surface waters in contrast to chemical analyses
- A combination of bioassays with different endpoints (at different trophic levels) is needed and depends on the water matrix
- Data analysis (chemical and biological data) and evaluation (using calculation models) is most important for conclusions regarding technical setup of the WWTP (cost effectiveness)

# Acknowledgements

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Grontmij



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# Thank you for your attention

for further information: [www.toxlab.de](http://www.toxlab.de)