Ecotoxicological assessment of ozone treatment in municipal wastewater treatment plants using in vivo bioassays

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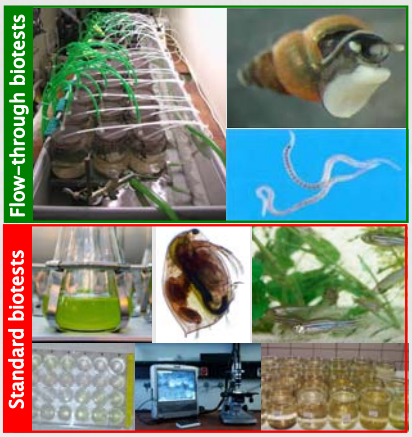
Introduction

A multitude of micropollutants has been detected in many running waters in Europe. These anthropogenic chemicals are only insufficiently removed in conventional wastewater treatment plants and discharged into the aquatic environment. Therefore advanced treatment processes have been developed and implemented on the large scale to increase the removal of micro-pollutants. A relatively new promising approach is the use of ozone as an oxidant for the elimination of micropollutants in wastewater treatment plant effluents. However, the use of ozone under economically feasible operation conditions does not result in a complete mineralization of organic substances but rather leads to partially oxidized transformation products.
In the joint research project "Study of metabolite formation during the use of ozone in municipal waste water treatment plants" (Project management: IWW, Muelheim, Germany, funded by the Ministry for Climate Protection, Environment, Agriculture, Nature Conservation and Consumer Protection of the German State of North Rhine-Westphalia (MKULNV) the question should be addressed, whether transformation products which elicit ecotoxicological or human toxicological effects are formed during ozonation. In this project potential effects of transformation products are assessed in real waste water on three large-scale sewage plants in Germany differing in their catchment areas. The toxicological examinations cover a broad spectrum of bioassays including in vitro and in vivo tests. Here the results of the in vivo bioassays will be presented and discussed.



Materials and Methods

Wastewater treatment plants

Transformation products formed by the ozonation in real waste water on three large-scale sewage plants differing in their catchment areas were assessed.

WWTP 1 – Bad Sassendorf – 12.000 PE
WWTP 2 – Duisburg-Vierlinden – 30.000 PE
WWTP 3 – Schwerte –50.000 PE

In vivo biotest battery

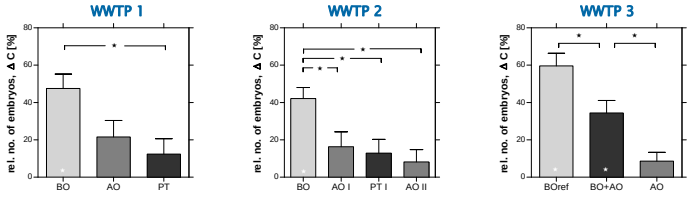
The applied in vivo test battery includes two on-site (flow-through) and four off-site acute and chronic tests with representatives of different trophic levels.

Flow-through biotests (28 days)
- Snail *Potamopyrgus antipodarum* – number of embryos
- Blackworm *Lumbriculus variegatus* – biomass

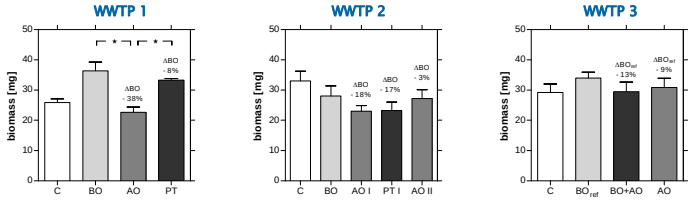
Static and semistatic standard biotests
- Green algae *Desmodesmus subspicatus* – growth rate after 72h
- Water flea *Daphnia magna* – acute – immobilisation after 48h
  chronic – population abundance after 21 days
- Zebrafish *Danio rerio* – Fish embryo test – mortality after 48h

Results

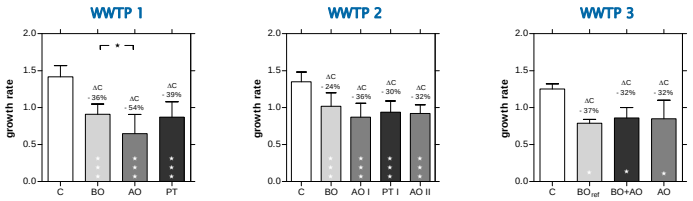
1 Freshwater snail *Potamopyrgus antipodarum*



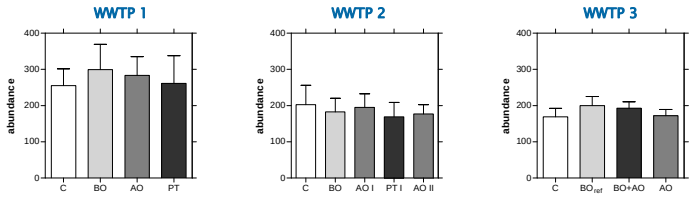
2 Blackworm *Lumbriculus variegatus*



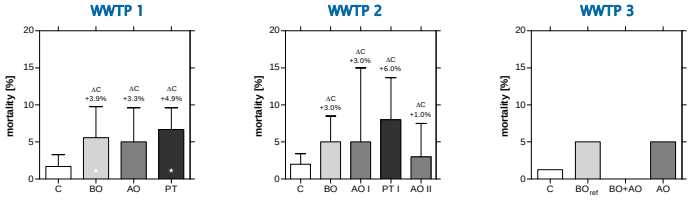
3 Green algae *Desmodesmus subspicatus*



4 Water flea *Daphnia magna*



5 Zebrafish *Danio rerio*



Legend

BO	before ozonation
BO_{ref}	reference treament without ozone
AO	after ozonation
PT	after post treatment
BO+AO	BO + recirculated AO

Conclusions

A After ozonation slight effects on the biomass of the blackworm could be observed in two of three WWTPs. The decrease in reproduction of the snail Potamopyrgus antipodarum indicated an effective elimination of estrogenic activity by ozone treatment.

B The standard test organisms showed toxic effects on the green algae before ozonation and increased toxicity after ozonation in two of three WWTPs. The water flea *Daphnia magna* and the zebrafish *Danio rerio* showed no indications of negative effects caused by ozone treatment.

C The in vivo biotest battery used was able to detect possible effects by ozone treatment and has been proved as sensitive tool although only original wastewater samples were tested without using enrichment procedures.

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