Technical University of Denmark

Environmental sustainability of waste water ozonation

Larsen, Henrik Fred; Hansen, Peter Augusto

Publication date:
2010

Document Version
Publisher's PDF, also known as Version of record

Environmental sustainability of waste water ozonation

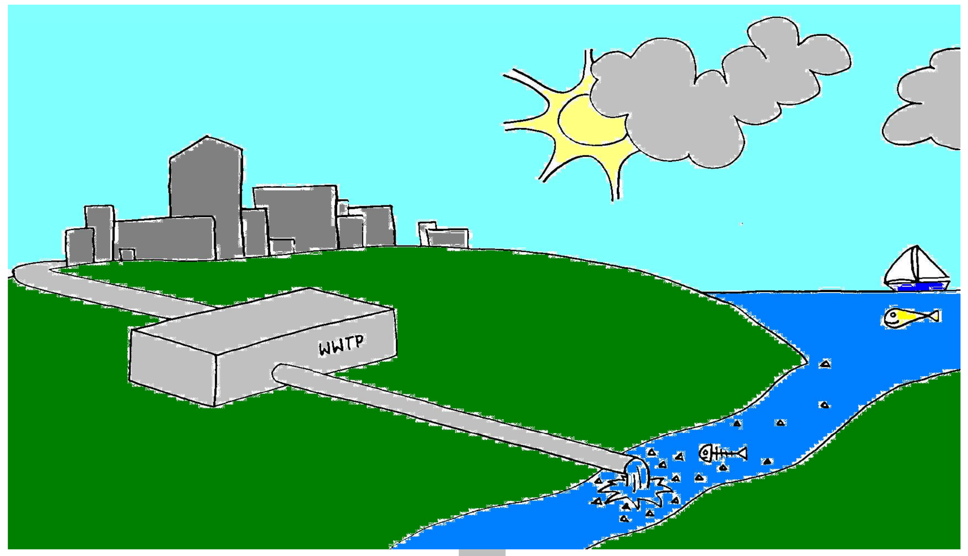
Henrik Fred Larsen and Peter Augusto Hansen, DTU
(corresponding author: hfl@man.dtu.dk)

Introduction

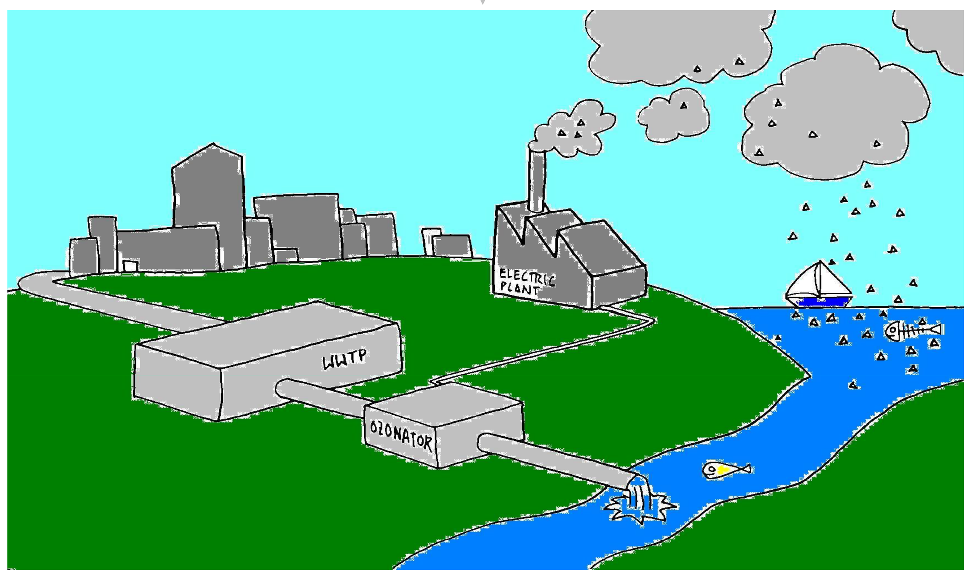
The EU FP6 project NEPTUNE has been going on for about 3,5 year and is now at the finalising stage. The project is related to the EU Water Framework Directive and the main goal has been to develop new and optimize existing waste water treatment technologies (WWTT) and sludge handling methods for municipal waste water. Besides nutrients, a special focus area has been micropollutants (e.g. pharmaceuticals, heavy metals). As part of the project a holistic based prioritisation among technologies and optimisations has been done and is based on life cycle assessment (LCA). The LCA's are performed as comparative LCA's and the concept of induced impacts as compared to avoided impacts is introduced in the life cycle impact assessment (LCIA) part. In total more that 20 different waste water and sludge treatment technologies have been assessed. This poster presents the LCA results from running the induced versus avoided impact approach on ozonation, and the impact of combining ozonation with sand filtration. The effect of including ecotoxicity effect end-points, for which the population survival relevance is debatable, on the estimation of ecotoxicity characterisation factors (CFs) is also shown. Furthermore, the effect on the "ozonation+sand filtration" LCA impact profile of including more micropollutants (9 metals) and phosphorus is illustrated.

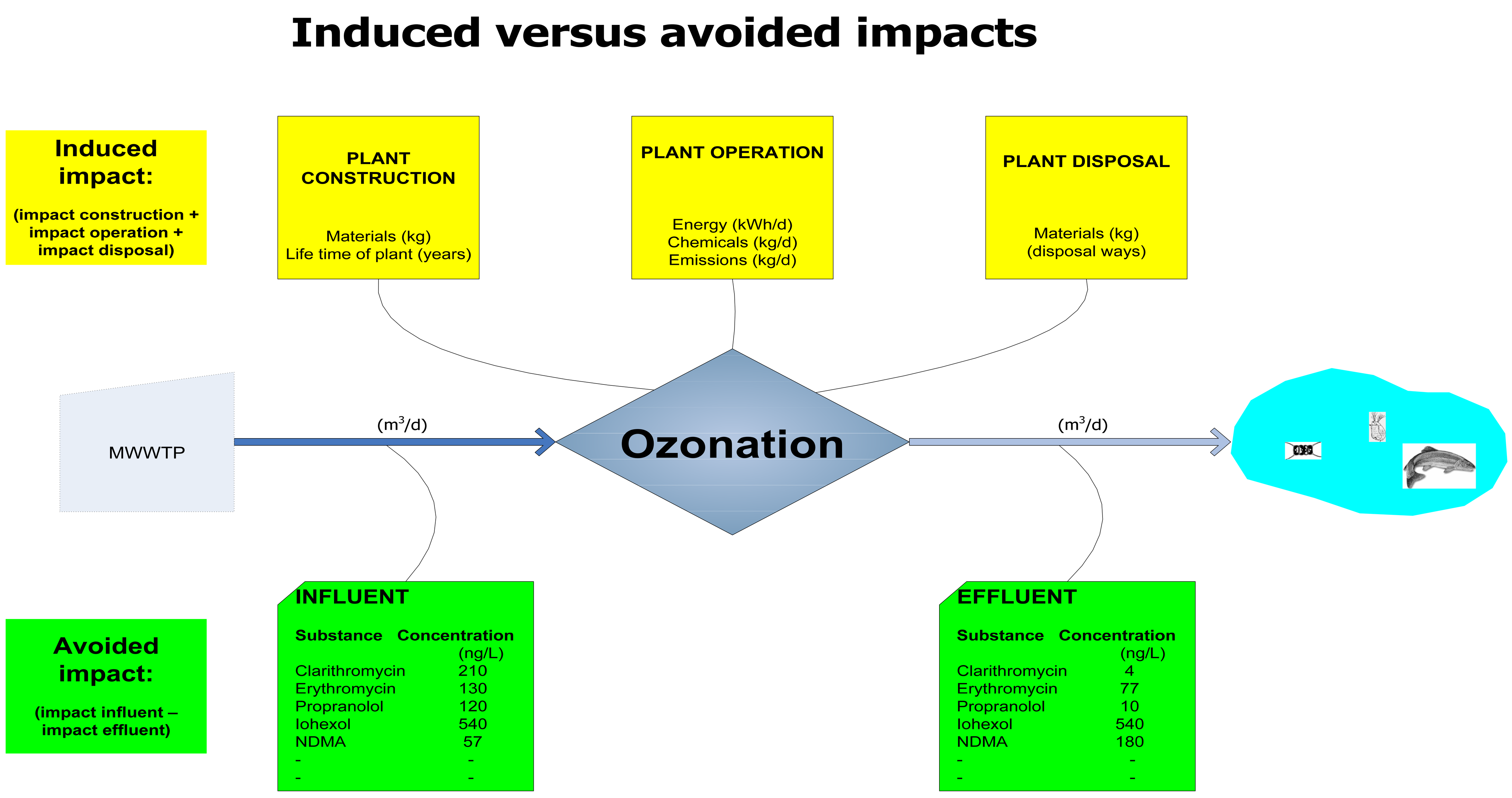
Methodology

Ozonation is a post treatment technology and the waste water treated is therefore the effluent from a municipal wastewater treatment plant with conventional treatment of today but without any post-treatment, i.e. primary and secondary treatment only. Foreground data, i.e. the characteristics of this effluent (micropollutants content), is based on within NEPTUNE generated data and literature data which is also the case for the inventory data on the ozonation plant (energy consumption, concrete consumption etc.). Removal rates are based on NEPTUNE data. Background data, e.g. emissions from electricity production, is mainly from the EcoInvent 2.0 database. Consequential LCA is used, e.g. marginal for electricity production is assumed to be natural gas. Adapted EDIP97 LCA methodology is applied.

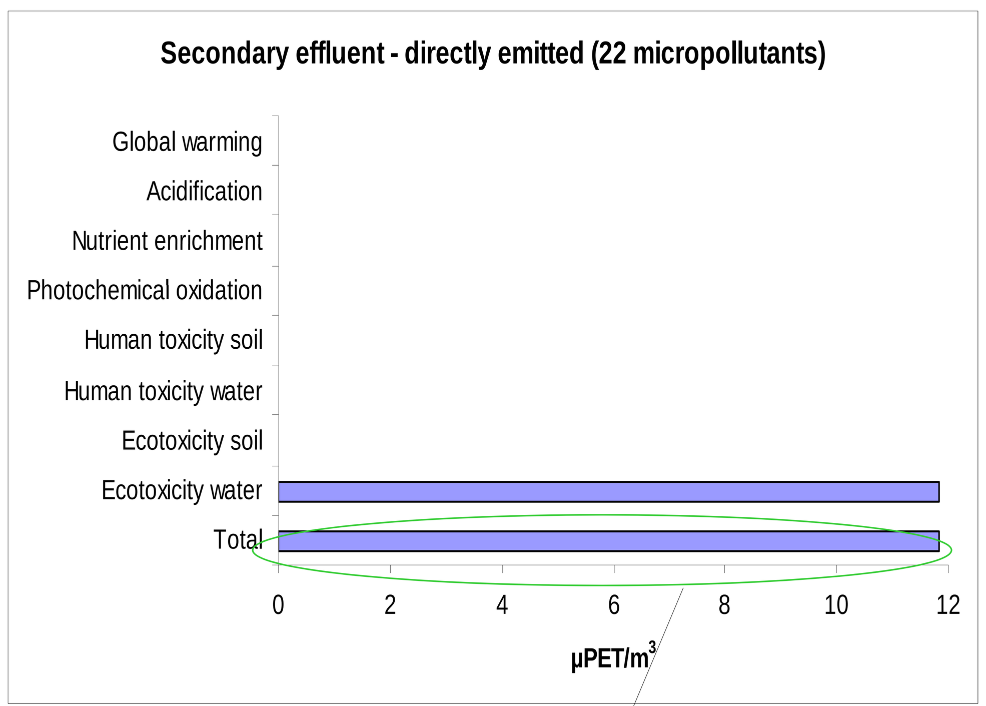


Sub-optimization?



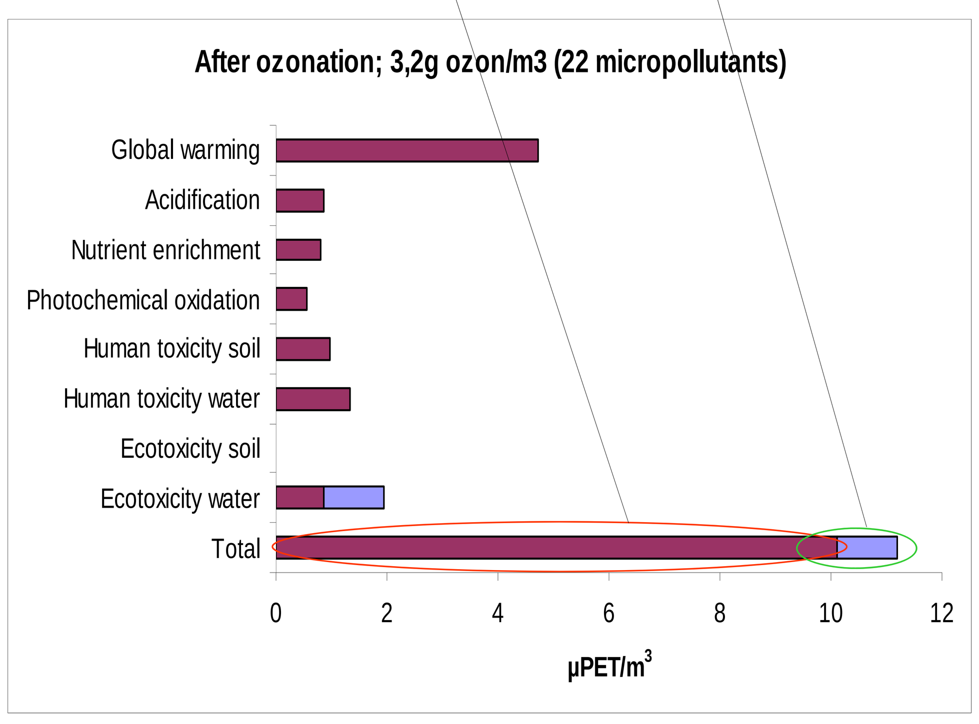


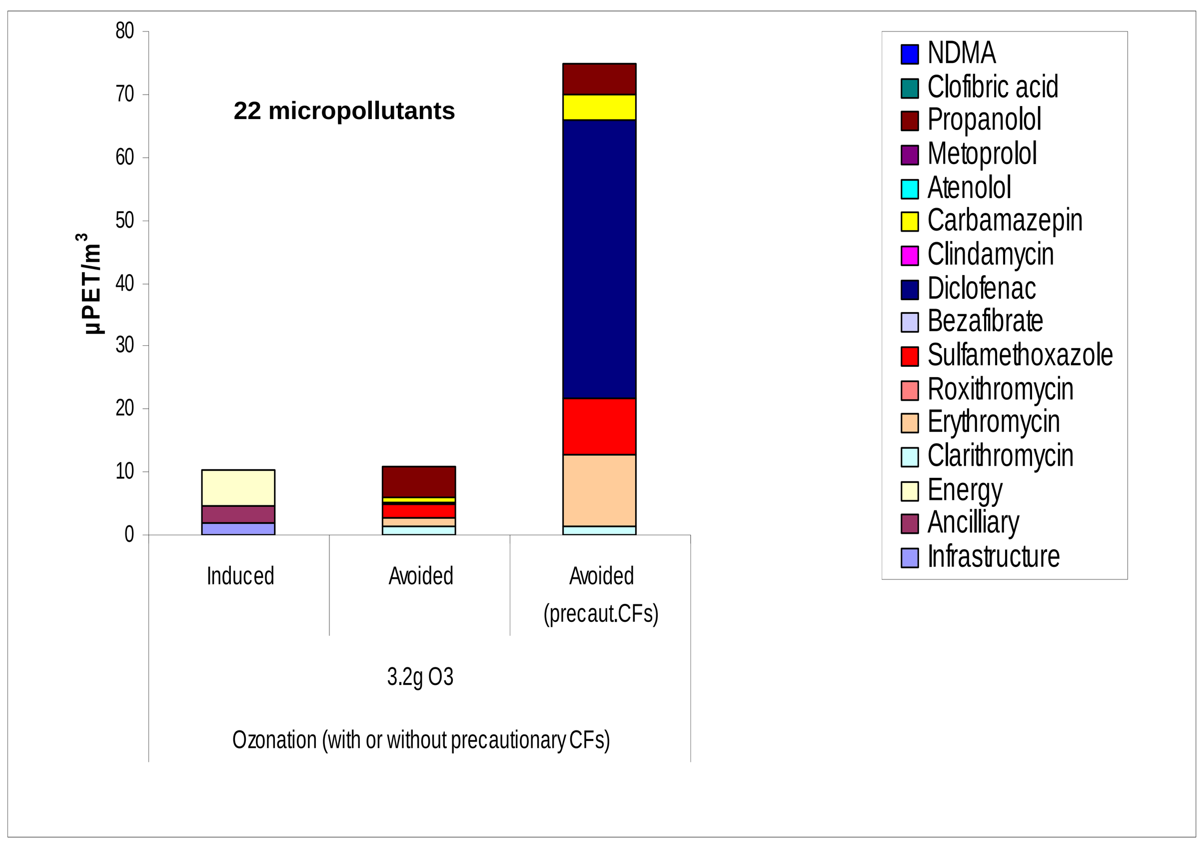
Results *(weighting factor = 1 for all impact categories)*

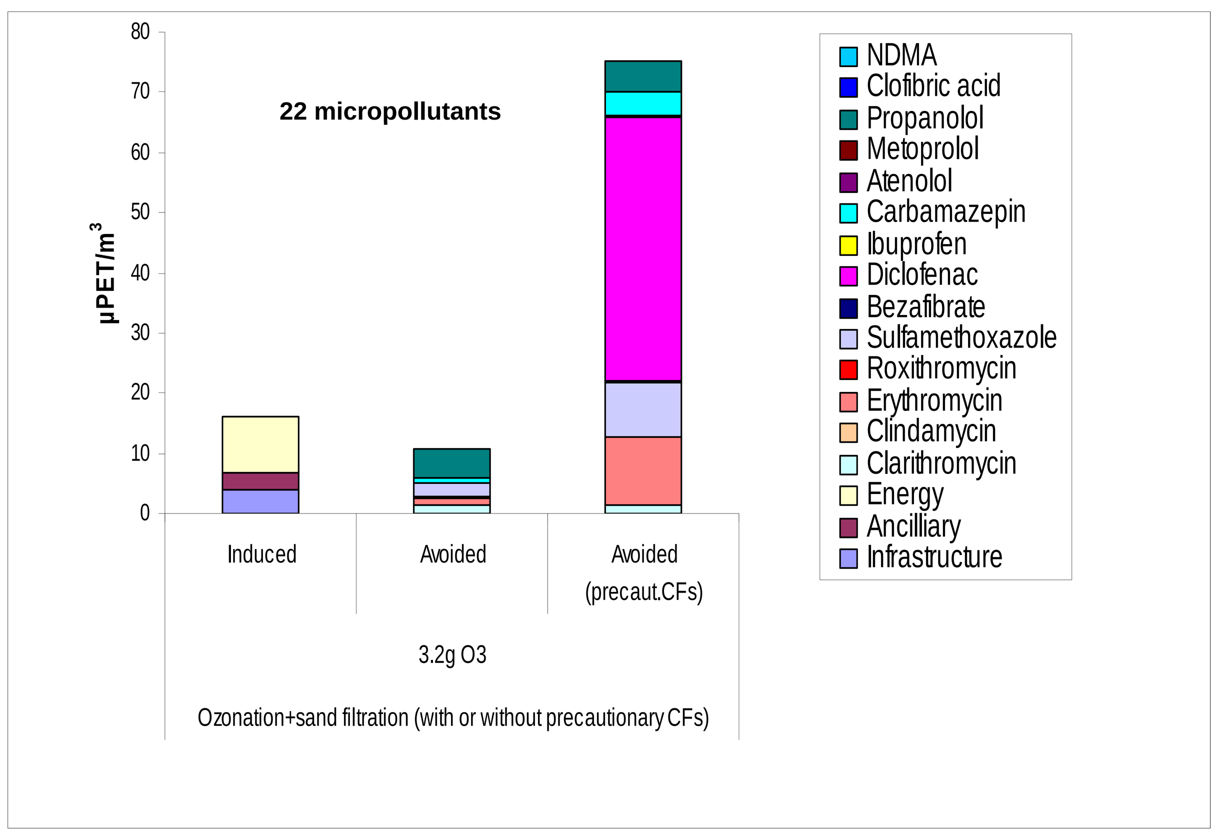


Avoided: 12 – 1 = 11 µPET/m3

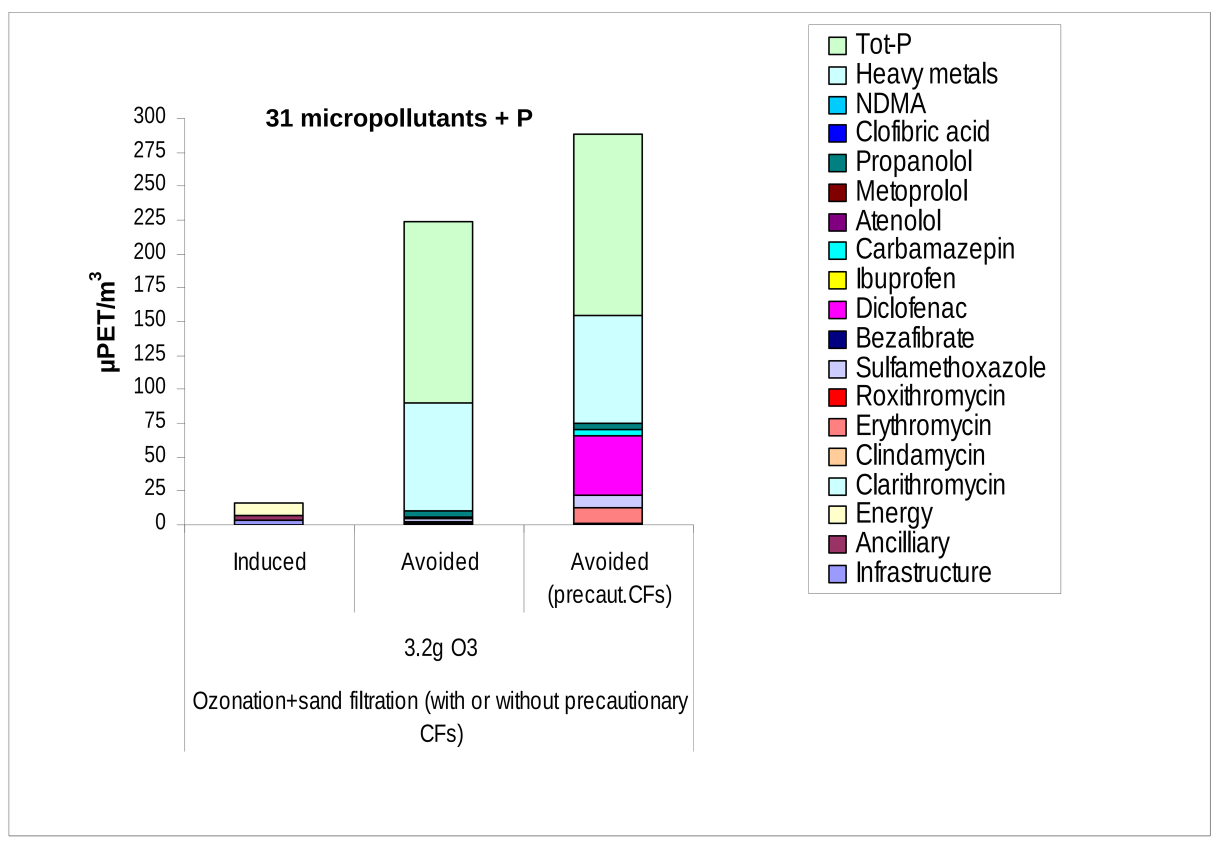
Induced: 10 µPET/m3







		Removal rate			Precuationary end-point	
	Inlet conc. (ng/L)	(3,2 g O_3/m^3)*	PNEC (µg/L)	CF (m^3/kg)	PNEC (µg/L)	CF (m^3/kg)
Atenolol	1600	0,80	330	2,99E+03		
Bezafibrat	82	0,62	2,3	4,35E+05		
Carbamazepin	710	1,00	2,5	4,00E+05	0,5	2,00E+06
Clarithromycin	170	0,96	0,31	3,23E+06		
Clindamycin	34	0,95	8,5	1,17E+05		
Clofibrinsäure	72	0,66	25	4,07E+04	5	2,00E+05
Diatrizoate	1800	0,00	11000	9,09E+01		
Diclofenac	1500	1,00	100	1,00E+04	0,1	1,00E+07
Erythromycin	99	0,80	0,20	5,00E+06	0,02	5,00E+07
Ibuprofen	91	0,00	96	5,21E+03	3	1,67E+05
Iohexol	190	0,00	7400000	1,36E-01		
Iopamidol	1100	0,24	380000	2,65E+00		
Iopromid	1800	0,26	100000	1,00E+01		
Metoprolol	410	0,88	76	1,32E+04	7,3	1,37E+05
Naproxen	230	0,99	190	5,18E+03		
NDMA (N-nitrosodimethylamin)	57	-1,71	40	2,50E+04		
Primidon	170	0,62	1400	6,94E+02		
Propanolol	95	0,90	0,050	2,00E+07		
Roxithromycin	50	0,82	2,8	3,56E+05		
Sotalol	430	0,98	300	3,33E+03		
Sulfamethoxazol	500	0,95	0,59	1,69E+06	0,15	6,67E+06
Trimethoprim	130	0,98	800	1,25E+03		



Conclusions

- ➢Based on the given assumptions (and the expected effect of including more micropollutants) results indicate that ozonation used for removal of organic micropollutants most probably is environmentally sustainable, i.e. avoided potential impacts are higher than induced potential impacts
- ➢However, problems with whole effluent toxicity (WET) from a risk assessment perspective (not shown)
- ➢Addressing the WET problem by including sand filtration significantly improves the sustainability profile (mainly due to added removal of heavy metals and tot-P)
- ➢Including ecotoxicity effect end-points with debatable populations survival relevance in the CFs (especially for diclofenac) have a significant impact on the impact profile for ozonation
- ➢Focusing on global warming a weighting factor of at least 30 – 45 is needed in order to reach a break-even between induced and avoided impacts for ozonation combined with sand filtration

DTU Management Engineering
Department of Management Engineering

Acknowledgment
This study was part of the EU Neptune project (Contract No 036845, SUSTDEV-2005-3.II.3.2), which was financially supported by grants obtained from the EU Commission within the Energy, Global Change and Ecosystems Program of the Sixth Framework (FP6-2005-Global-4). Thanks to Juliane Hollender, Eawag for supplying removal rates on pharmaceuticals