Retrofitting ozonation into existing plants

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March 14th 2019

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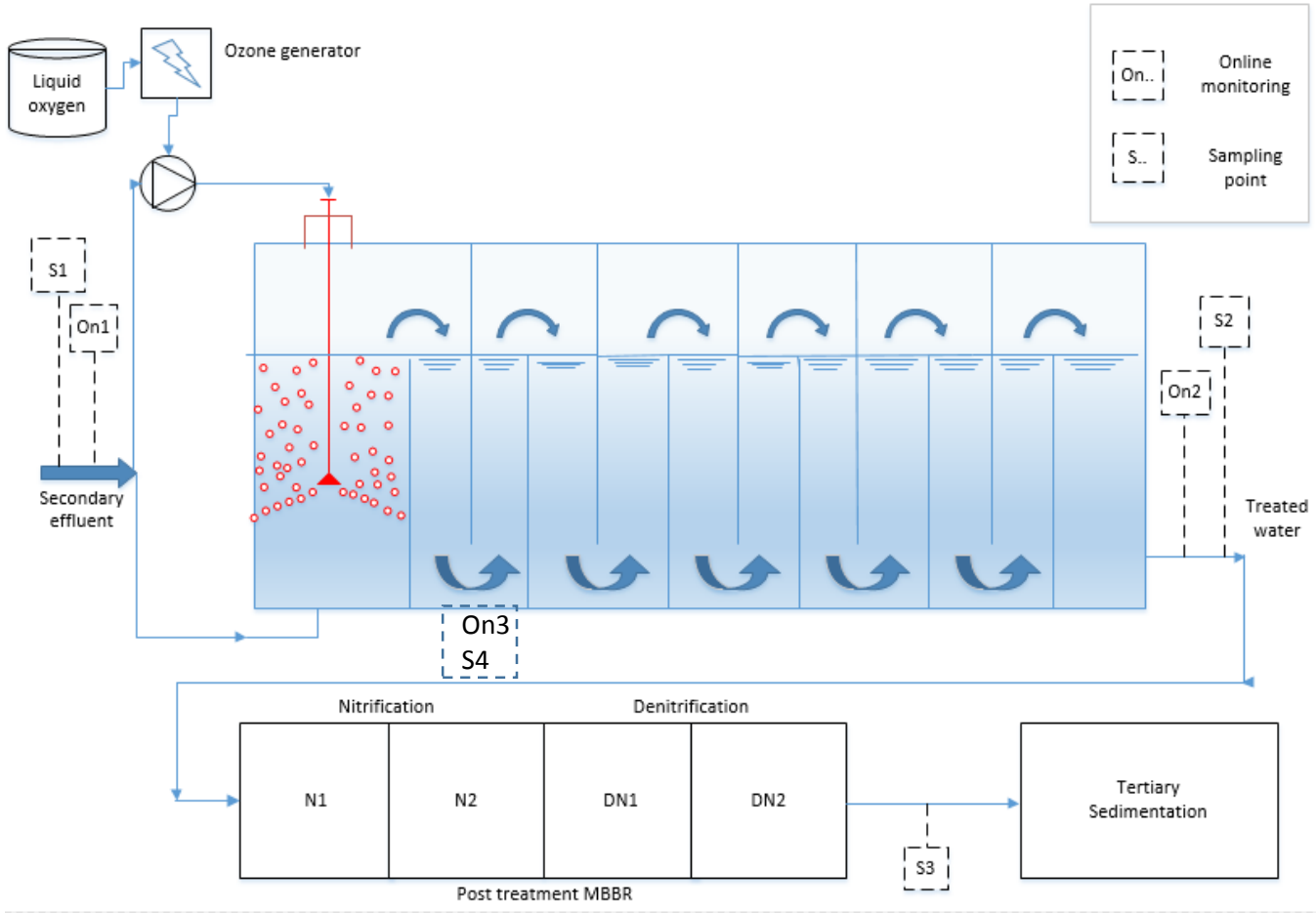
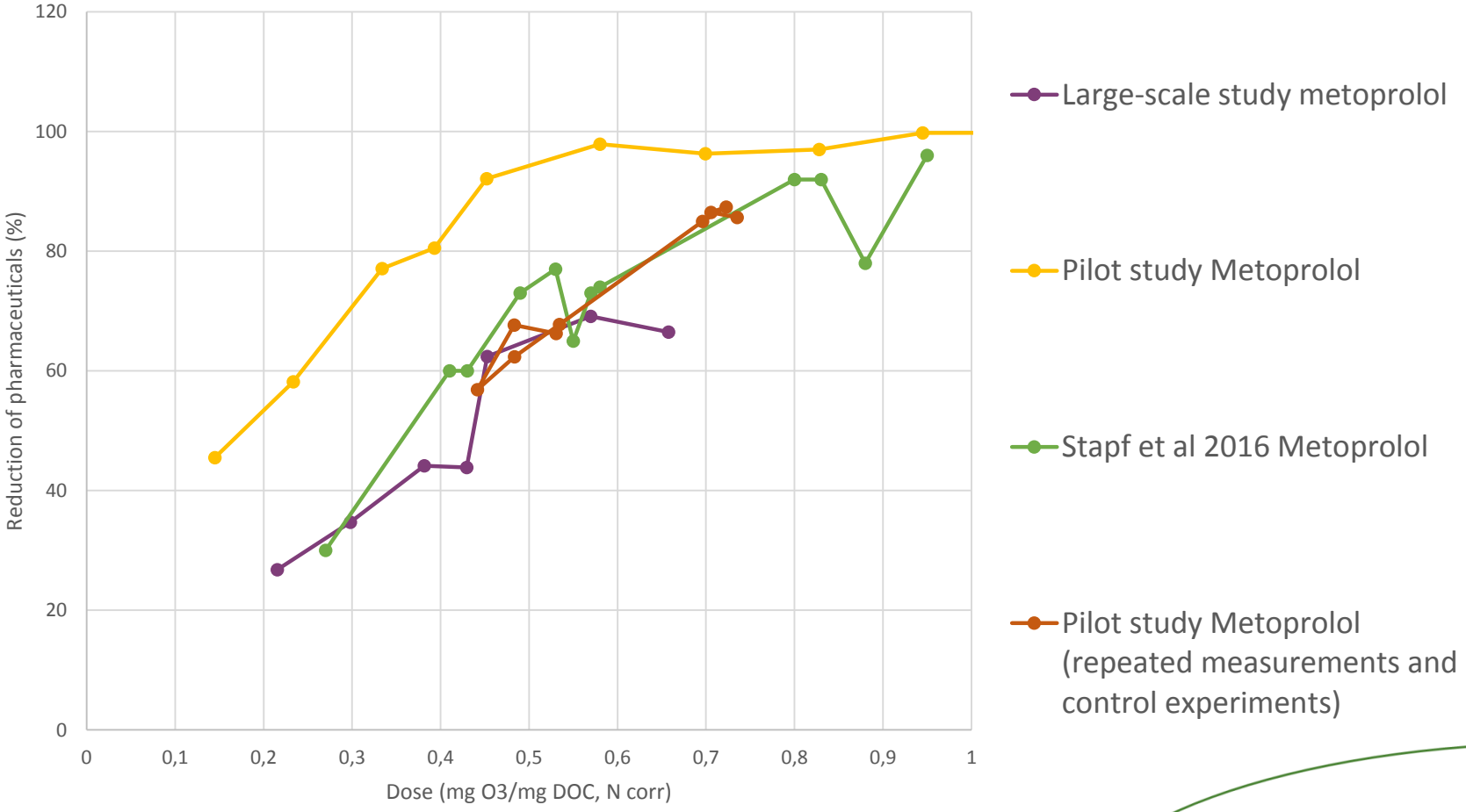
System – ozone reactor and MBBR



Comparison pilot and full scale studies



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Ozone production capacity – Risc matrix

Pilot study

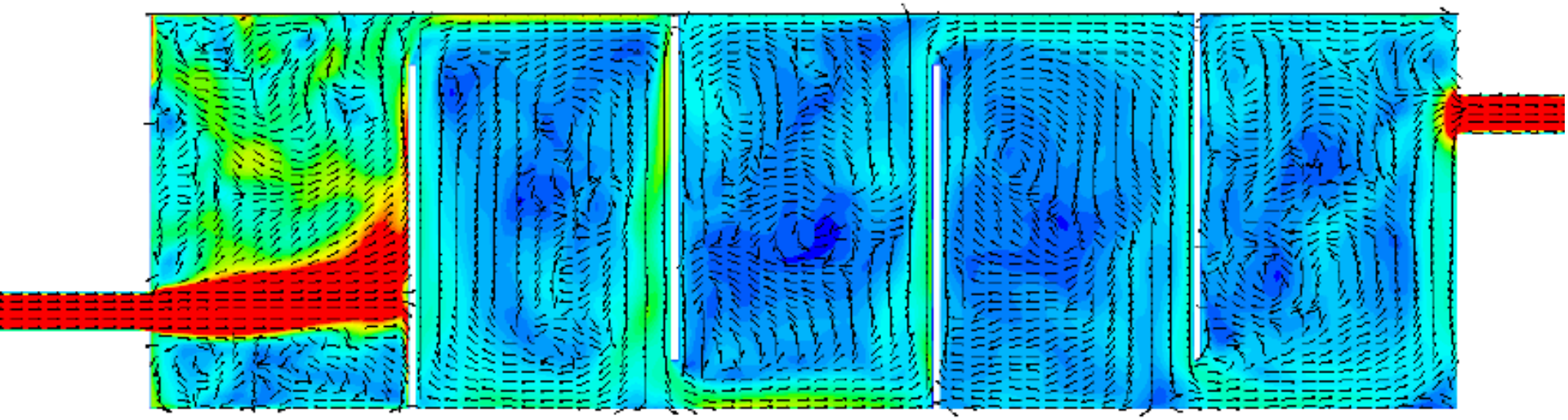
Pilot study	5 mg O_3/L	0.47 mg O_3/mg DOC, N corr			
Substance	**MEC (µg/L)**	**NOEC (µg/L)**	**Assessment factor**	**Dilution recipient**	**MEC/PNEC quota**
Oxazepam	0,1	1,8	1000	27	2,058
Metoprolol	0,25	1	50	27	0,463
Trimethoprim	0,001	0,29	100	27	0,013
Ibuprofen	0,14	10	10	27	0,005
Ciprofloxacin	0,009	1,2	10	27	0,003
Atenolol	0	1000	100	27	0,000
Citalopram	0	105	100	27	0,000
Diclofenac	0	0,5	10	27	0,000
Propranolol	0	0,5	50	27	0,000
Sulfamethoxazole	0	250	100	27	<0,01

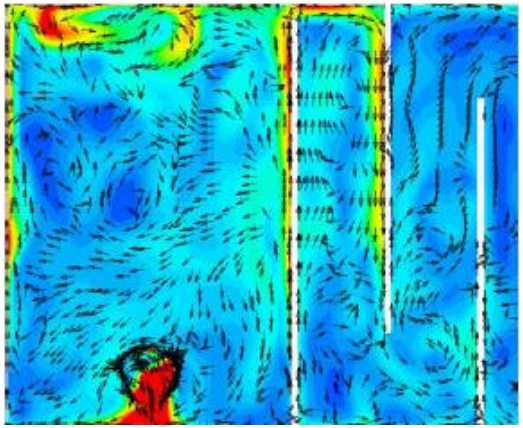
Full scale

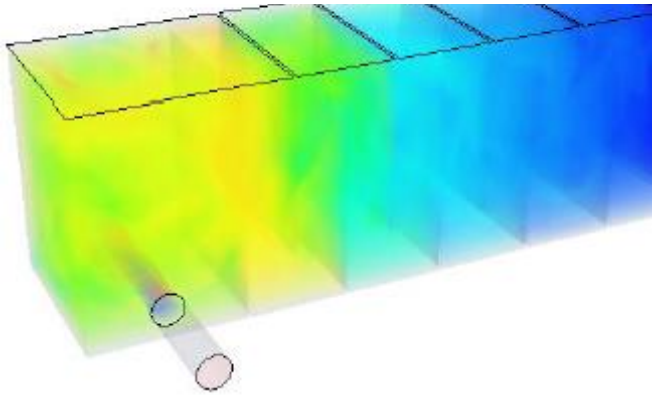
- High assessment factor for Oxazepam
- Metoprolol below high risc level: 0.73 mg O3/mg DOC, N corr (~10 mg O3/L)

Large-scale study	9 mg O_3/L	0,58 mg O_3/mg DOC, N corr			
Substance	**MEC (µg/L)**	**NOEC (µg/L)**	**Assessment factor**	**Dilution recipient**	**MEC/PNEC quota**
Oxazepam	0,16	1,8	1000	27	3,292
Metoprolol	**0,76**	**1**	**50**	**27**	1,407
Trimethoprim	0,01	0,29	100	27	0,128
Diclofenac	**0,11**	**0,5**	**10**	**27**	0,081
Citalopram	0,04	105	100	27	0,001
Atenolol	**0,28**	**1000**	**100**	**27**	0,001
Sulfamethoxazole	0,01	250	100	27	0,000
Propranolol	**0**	**0,5**	**50**	**27**	0,000
Ciprofloxacin	<lod	1,2	10	27	0,000
Ibuprofen	**<lod**	**10**	**10**	**27**	0,000

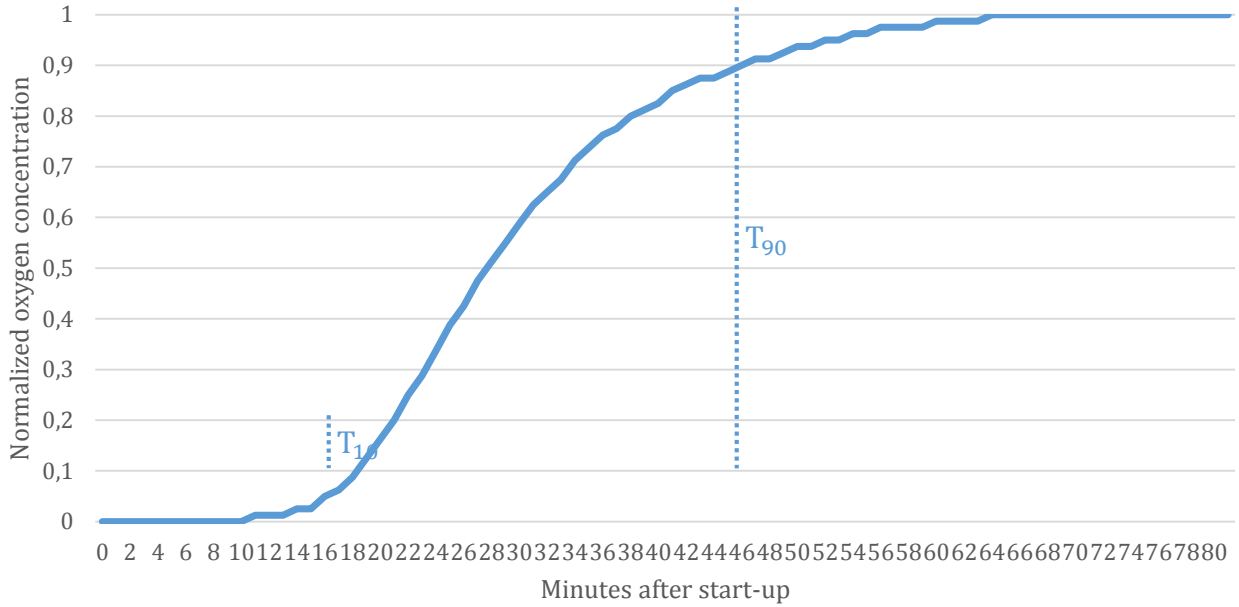
Designing a plug-flow reactor, CFD-simulation







Residence Time Distribution and plug-flow evaluation



$T_{10} = 19$ min $T_{90} = 46$ min at 2000 m³/h

$$T_{TDT} = \frac{V}{Q} = 16.7 \text{ min}$$

- Baffle factor BF: $\frac{T_{10}}{T_{TDT}} = 1.13$ (1.0 for plug flow)
- Morril index MI: $\frac{T_{90}}{T_{10}} = 2.42$ (1.0 for plug flow)

Things to bear in mind when specifying the design

- The current process design
  Any obvious choice where to retrofit the ozone plant?
  Exixting post treatment e.g. sandfilter or MBBR

- Particles in bio treated water
  Blocking equipment
  Blocking filters
  Sludge →Foaming. By-passing the plant?

- Freezing problems during stops

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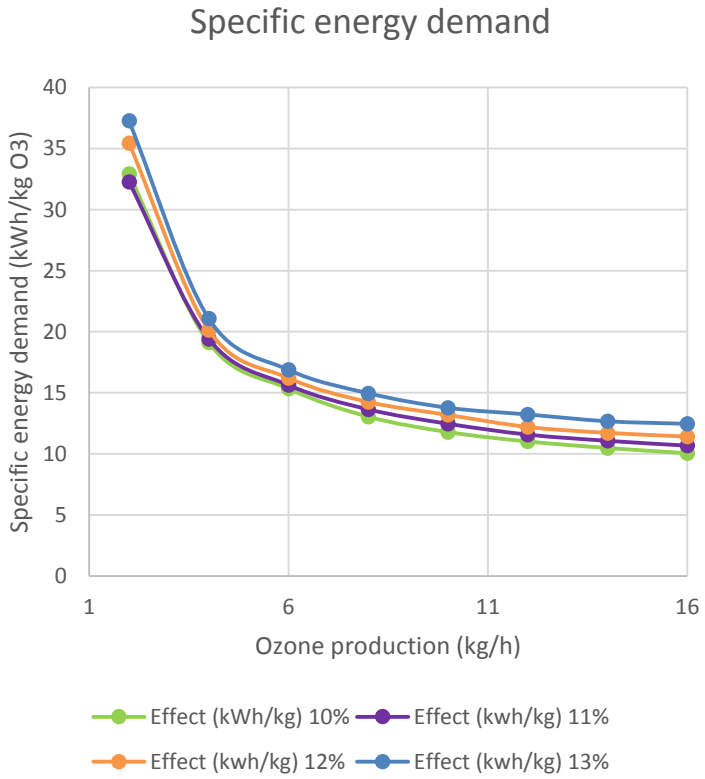
Things to bear in mind when specifying the design

- Cooling
  - Biofilm growth in HEX
  - Increased temp -> incr ozone degradation -> incr energy consumption
- Power Capacity
- Specific energy demand



CWPharma

Tekniska verken

Working environment

- Ozone
  Very powerful oxidizing agent
- Oxygen
  Oxygen reacts explosively with fats
  Asfalt contains bitumen → Gravel around the LOX tank
- Noice 1400 Hz
- Magnetic field
- Ozone resistant materials
  Stainless steel
  PTFE
  No fat!!
- **All this can be dealt with preventive measures and good practices**