MICROINQUINANTI E CONTAMINANTI EMERGENTI
Testimonianze, Soluzioni e Prospettive
Milano – 11 e 12 Giugno 2018

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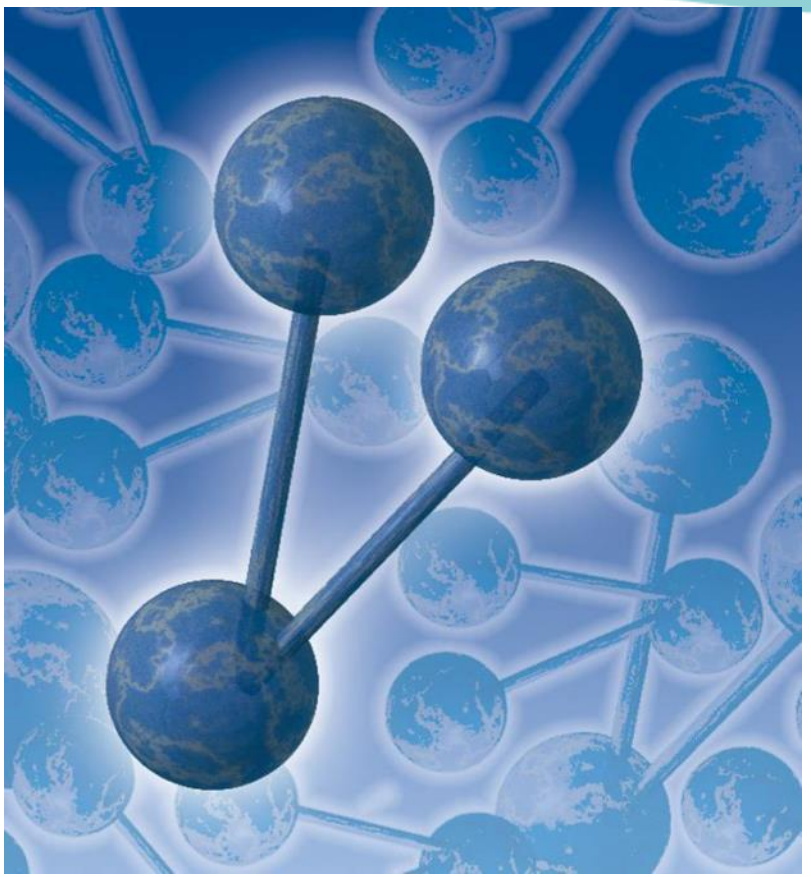
L'ozono nella rimozione dei microinquinanti dalle acque reflue e potabili

Ing. Federico Dallera

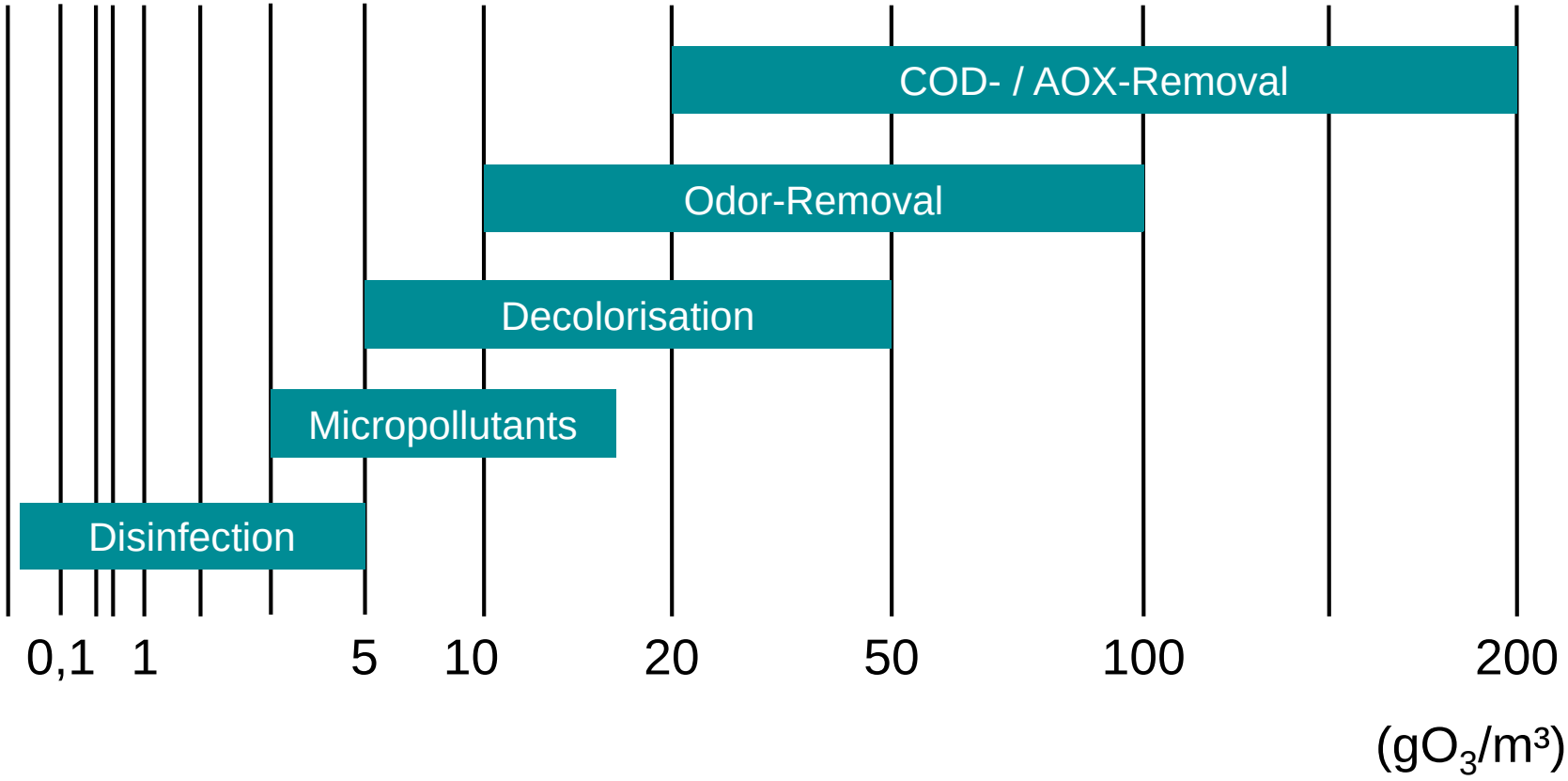
Ozone - Oxidation
Applications

- Removal of biofilms e.g. cooling water
- Disinfection in drinking water
- COD – removal in waste water
- Removal of toxic substances:
  Phenols, Pesticides, PPCP
- Decolorisation
- Air treatment
- Bleaching of pulp for paper industry
- ...



Ozone - Oxidation

Dosages for different applications



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Removal of Emerging Contaminants (EC) by ozone

- Basics -

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Removal of Emerging Contaminants (EC)
Groups of substances

Pharmaceuticals (API):

substances which will be **excreted** after use.

Endocrine disrupting compounds (EDC):

substances which cause **hormonal effects**.

Personal care products (PCP):

perfumes, sun protections, cleaning agents etc.

Pesticides:

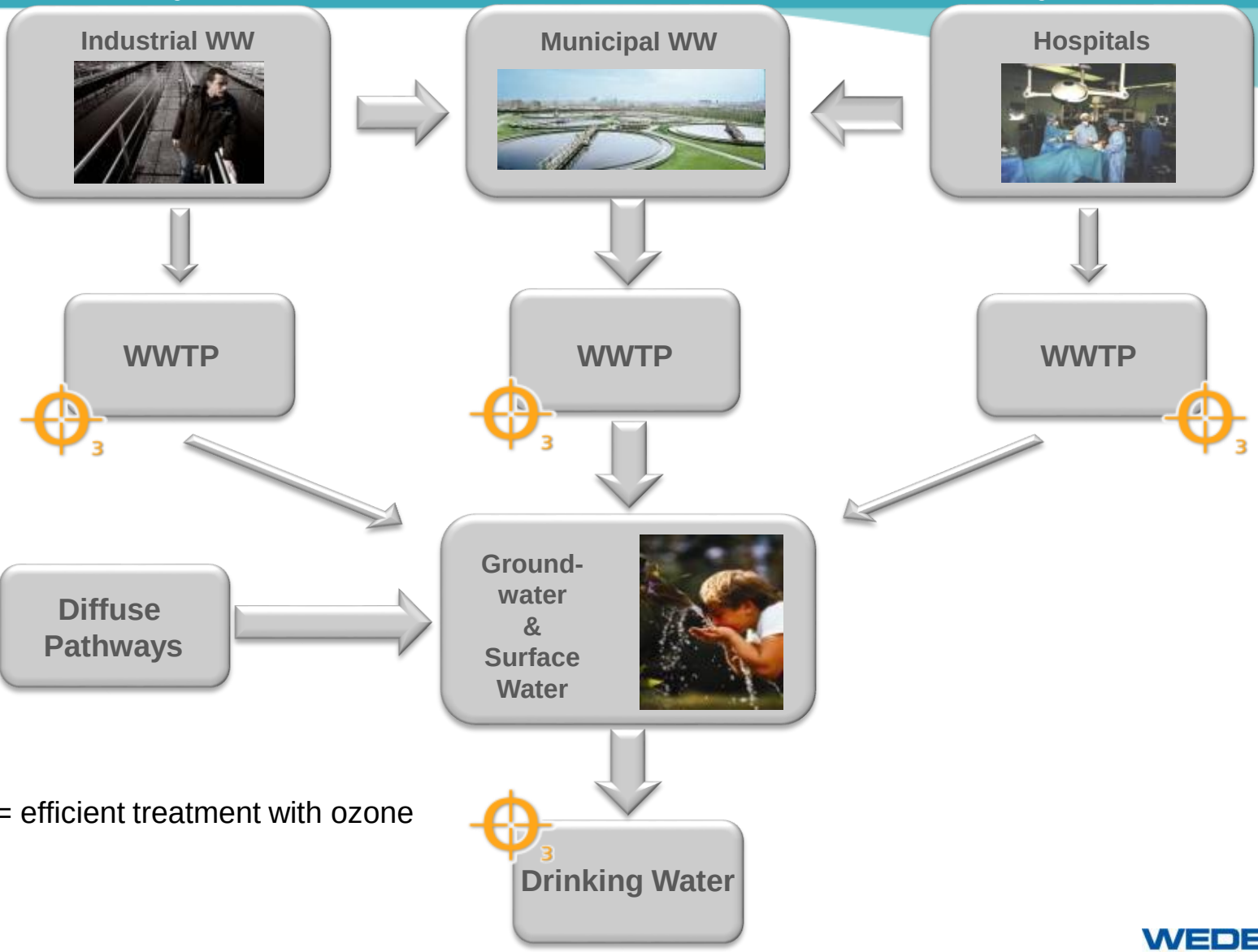
entry into the water cycle from households and agriculture

Industrial Chemicals:

emissions of specific substances from industrial processes

Sources and Pathways of EC‘s

Main pathways of EC‘s and EDC‘s into the water cycle



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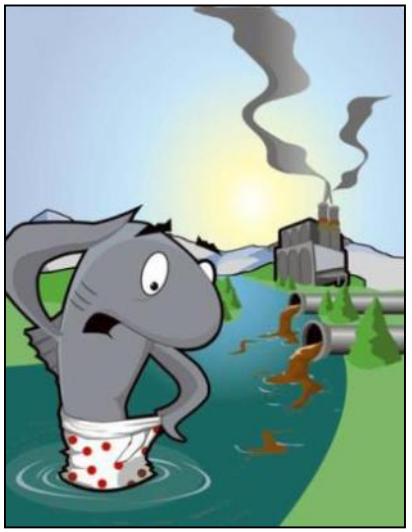
Endocrine Disrupting Compounds (EDC's)

The problem

The occurrence of endocrine substances in our wastewater and drinking water lead to resistant changes in our ecosystem

In fish was found

- increased hermaphroditism
- declining number of sperm



Potential impact to humans

- Reduction of fertility
- Higher number of tumors

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Annual drug consumption

Example: Switzerland

Diclofenac *analgesic*	***5.411 kg/a***
Carbamazepine *anticonvulsant*	***3.912 kg/a***
Clarithromycin *antibiotics*	***1.597 kg/a***
Metoprolol *beta blocker*	***4.381 kg/a***
Ethinyl estradiol *synthetic estrogen*	**4 kg/a**
Sulfamethoxazole *antibiotics*	***2.427 kg/a***
Benzotriazole *Corrosion inhibitor*	***16.000 kg/a***

More than 50% of the active substances are excreted unchanged and recovered in the effluent.

Source: Götz, C.W., R. Kase und J. Hollender (2010). „Mikroverunreinigungen - Beurteilungskonzept für organische Spurenstoffe aus kommunalem Abwasser“. Studie im Auftrag des BAFU. Eawag, Dübendorf

Removal of Emerging Contaminants by ozone

- Technical solutions and required components -

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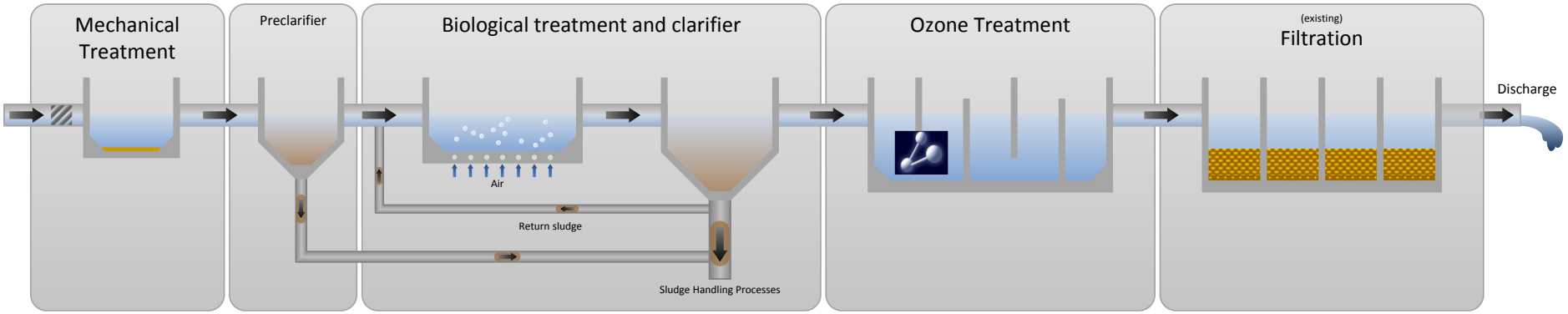
Ozone on WWTP
Applications



Detoxification
Side-stream applications e.g. removal of hard COD

Sludge reduction
Deodorization

Emerging compounds
Disinfection
Decolorisation
COD-Reduction

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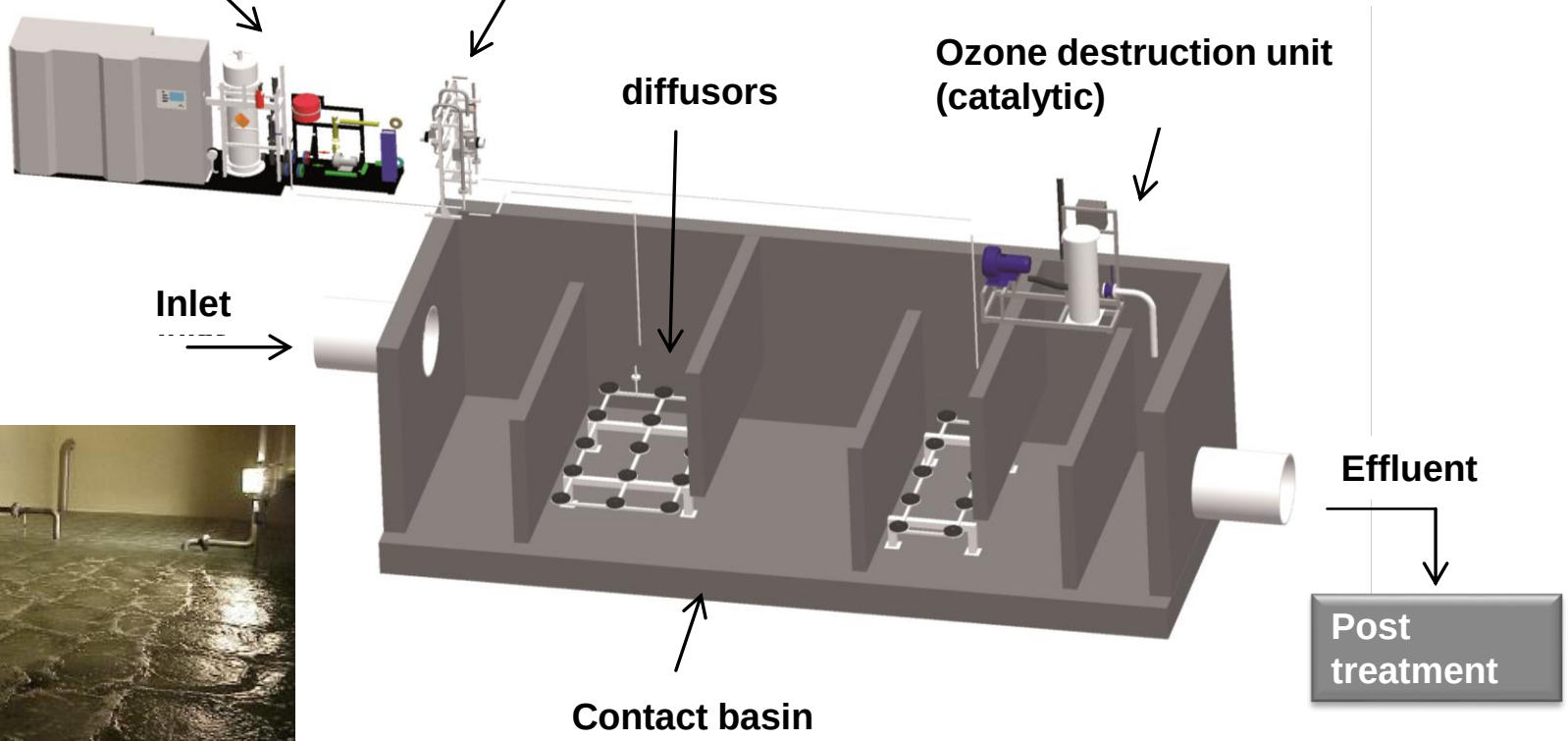
Ozone-based process for EC oxidation
Required components



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Ozone plants

PLC
+
SCADA

Ozone destroyer

Feed gas

Ozone generator

Cooling water

Instrumentation

Contact systems

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Ozone – gas transfer
Diffusor or Venturi

	PRO	CONTRA
Diffusor 	• Good gas transfer • Small scope for installation • Low investment costs • Low operating costs	• Limited in minimum gas flow • Bio-fouling possible • Diffusor system inside the tank
Venturi 	• Very high gas transfer • Expanded operating range for gas flow • Maintenance outside the contact basin	• Limited minimum water flow (fixed flow) • Enlarge scope of installation • Increased operating costs by additional pumps • Increased investment costs

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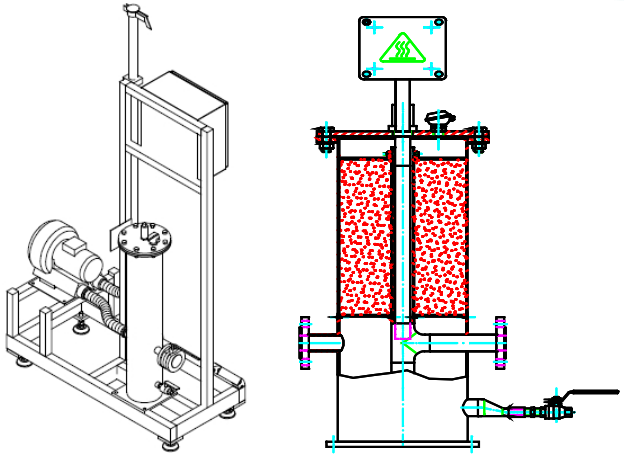
Offgas treatment and measurement



Catalytic Ozone Destroyer
1 – 4.200 Nm³/h

LC 400
0 – 0,02 mg/Nm³

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Ozone generator

Safety

Safety Technologies (Scope)	Safety aspects (excluded)
Ambient air monitor ozone	Lockable operating room
Ambient air monitor oxygen	Emergency button and display outside (optional)
Horn and flash light	Gas mask etc.
Emergency button	Additional space for maintenance and operation
Permanent control of all components	Forced ventilation
Vacuum control (Venturi)	
Vacuum control (basin)	
Control of resources (e.g. temperature cooling water, pressure…)	

Removal of Emerging Contaminants (EC) by ozone

- Process controls -

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Process Controls

Differentiation

Differentiation necessary in

1. Control of the **ozone generator** to produce required ozone mass (included)

2. Control concepts **to calculate** the required ozone mass based on various parameter (based on customers requirements)

Process Controls

Parameter for calculation of required ozone mass

	Flow-proportional	DOC-based	SAC inlet	SAC-Removal
Input	Ozone dosage in mg/L	Specific ozone dosage $Z_{spez,DOC}$	Specific ozone dosage $Z_{spez,SAC}$	Percentage SAC-removal
Control concept	Calculation based on current inlet flow	Calculation based on current inlet flow and DOC concentration	Calculation based on current inlet flow and SAC concentration	Adoption of ozone generator based on the difference between inlet and effluent value
Parameter	Flow	Flow, DOC	Flow, SAC	Flow, 2xSAC

DOC = Dissolved Organic Carbon --- SAC = Spectral Absorbance Coefficient @ 254 nm

Correlation between DOC or SAC to EC's concentration was investigated in several research projects but has to be checked individually. All described control concepts are installed in large scale systems and proven.

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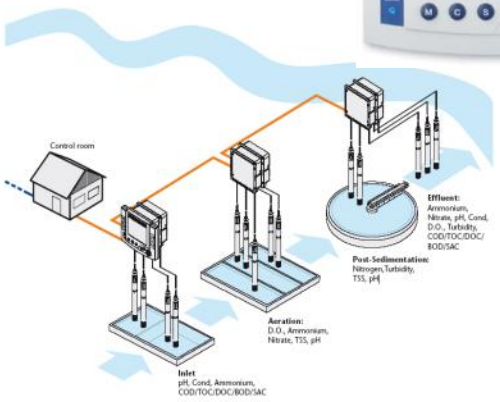
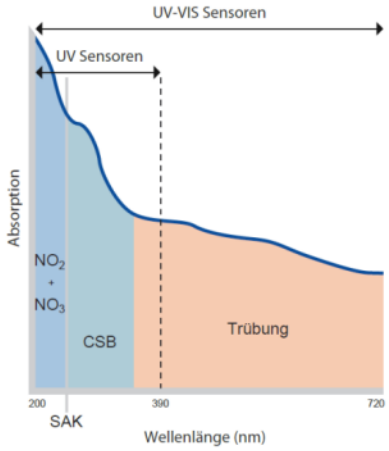
WTW Sensors

IQ SENSOR NET XT



- Intelligent Network up to 20 sensors
- Mobile Interface
- Expendable by pre-calibrated Plug&Play sensors
- Communication: 4-20 mA, PROFIBUS, MODBUS RTU, Ethernet IP, MODBUS TCP

WTW CarboVis and NiCaVis



256 wave length
- Improved correlation
- Improved corrections of turbidity
- Improved compensation of varying concentrations

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Removal of Emerging Contaminants (EC) by ozone

- Design of contact basins -

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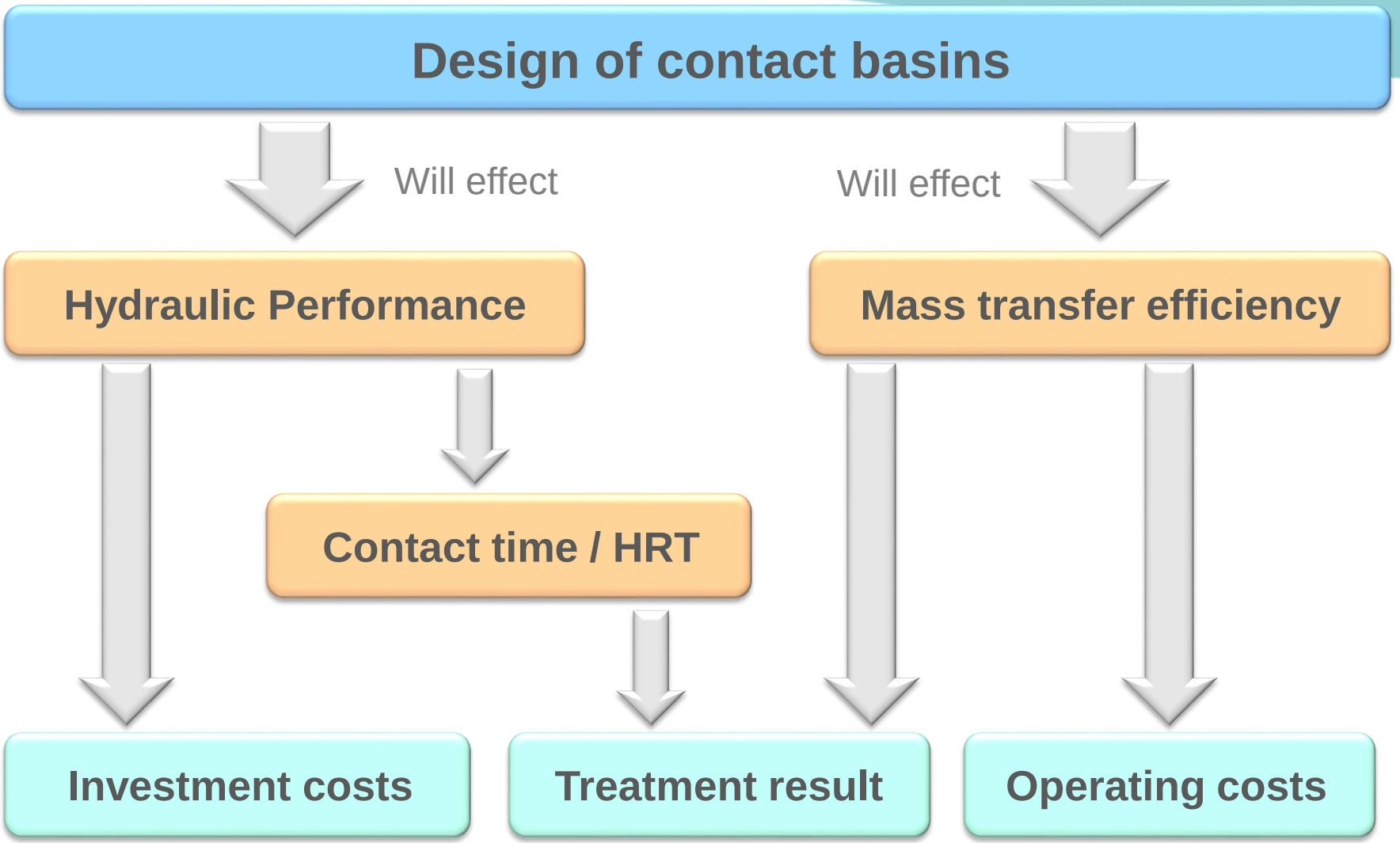
Design of contact basins

Why „design“?



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Design of contact basins

Controllable parameters

Expectations:

- **Improved utilization of existing volumes**
- **Improved flow and time distribution**

Controllable parameters

Geometric parameters

- **Depth (water level)**
- **Number of segments**
- **Area of segments**
- **Wall distances**
- **Design of free passages**
- **Design of inlet**

Diffusors

- **Bubble size**
- **Type and model**
- **Arrangement**
- **Incident flow**
- **Distances**
- **Operating ranges**

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Removal of Emerging Contaminants (EC) by ozone

- References -

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References
Participation in research projects

Project	Town / Country	Partner	WWWTP	Ozone dosage [g/m³]	Start / End
EU-Project Poseidon	Brunswick / Germany	Different EU Partner	Brunswick / Germany	5 - 15	Januar y 2001 - June 2004
EU-Project Poseidon	Opfikon / Switzerland	EAWAG	Opfikon / CH	5 - 15	November 2003
Research project	Stuttgart / Germany	University Stuttgart	Büsnau / Germany	5 - 15	December 2003 – May 2005
Pilotox	Berlin / Germany	TU Berlin	Ruhleben / Germany	5 - 15	December 2004 – June 2005
Research project	Leiden AD / The Netherlands	Hoogheemraadschap van Rijnland	Leiden AD / NL	5 - 15	March 2008 – November 2008
KomOzon	Vienna/ Austria	TU Wien	Vienna/ Austria	5 - 15	June 2007 - October 2010
Research project	Ilkestone / GB	Severn Trent	Ilkestone / GB	3 - 5	July 2007 – 2009
Strategy Micropoll	Regensdorf / Switzerland	BAFU / CH; EAWAG	Regensdorf / CH	1 - 10	July 2007 – October 2008
Strategy Micropoll	Lausanne / Switzerland	BAFU / CH; EAWAG; University Lausanne	Lausanne / CH	1 - 10	June 2009 - July 2010
TransRisk	Darmstadt / Germany	BfG; TU Darmstadt	Darmstadt / Germany	1 - 10	Nov. 2011 – Dec. 2015
KomOzAk	Vienna / Austria	TU Wien	Vienna/ Austria	5 - 15	January 2013 – March 2016
SchussenAktiv+	Eriskirch / Germany		Eriskirch / Germany	1 - 10	September 2012 – April 2015

WEDECO is for more than 13 years a partner for the removal of EC's

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References

Large scale references

Project	Operator / Partner	Town	Country	Year	Flow [m³/h]	Capacity [kg/h]	Application H = Hospital/ M = Municipal WWTP
“Strategy Micropoll”	BAFU, EAWAG	Regensdorf	Switzerland	2007	430	5	M
“Strategy Micropoll”	BAFU; EAWAG; Uni Lausanne	Lausanne	Switzerland	2009	360	5	M
Bad Sassendorf	Emschergenossenschaft	Bad Sassendorf	Germany	2009	300	4.8	M
Schwerte	Ruhrverband	Schwerte	Germany	2011	1,100	7	M
Duisburg-Vierlinden	Wirtschaftsbetriebe Duisburg	Duisburg-Vierlinden	Germany	2011	400	2 x 1.95	M
Warburg	KUW Warburg AÖR	Warburg	Germany	2016	660	2 x 1.7	M
Espelkamp	Stadtwerke Espelkamp	Espelkamp	Germany	Planned 2017	435	3.5	M
Köln-Rodenkirchen	STEB Köln	Cologne	Germany	2016	205	1.5	M
Weißenburg	Stadtwerke Weißenburg	Weißenburg/ Bayern	Germany	Planned 2017	450	2.7	M
Aachen-Soers	Wasserverband Eifel-Rur	Aachen	Germany	Planned 2017	10,800	3 x 10.8	M
ARA Werdhölzli	ERZ Zürich	Zurich	Switzerland	Planned 2018	23,400	8 x 19.1	M
ARA Eich	Zweckverband Bassersdorf	Bassersdorf	Switzerland	Planned 2017	900	2 x 1.75	M
ARA ProRheno	ProRheno	Basel	Switzerland	Planned 2018	11,000	3 x 12	M
ARA Porrentruy	Syndicat intercommunal pour l’épuration des eaux usées de Porrentruy et environs (SEPE)	Porrentruy	Switzerland	Planned 2019	612	4.2	M
St. Pourçain-sur-Sioule	Ville de St. Pourçain / SEMERAP	St. Pourçain	France	2013	90	1.2	M
Simrisham	Simrishams Kommun	Simrisham	Sweden	2015	220	2	M
Krankenhaus Waldbröl	Krankenhaus Waldbröl	Waldbröl	Germany	2010	32	0.4	H
Marienhospital	Emschergenossenschaft	Gelsenkirchen	Germany	2011	25	0.4	H

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References

WWTP – Short summary

Initial situation

Plant size:	25.000 PE + max. 15.000 PE druing campaign of sugar beets harvesting	
Micropollutants: (increased Conc.)	Diclofenac Carbamazepin Sufamethoxazol Benzotriazol	(Pain killer) (Antiepileptic) (Antibiotic) (dish washer detergent, corrosion inhibitor)
Target: improve	Improvement of WW effluent quality to water quality in recieving small river (Diemel), lowest operating cost	

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References

WWTP – Ozone system

Data: Ozone + Downstream Bioreactor

Design flow:	**2 x 330 m³/h (max. dry weather)**
Flow min. - max.:	**58 - 660 m³/h**
Contactor:	**2x 125 m³ concrete, 5 m depth**
Hydraulic retention time:	**~ 20 min**
Ozone generator:	**2 x WEDECO SMOevo 410**
	(max. 1,8 kg/h each)
Post treatment:	**2x 55 m³ Moving Bed Bio Reactor (incl. Mixer)**
Installation / Start up:	**04 / 2016 – 07 / 2016**

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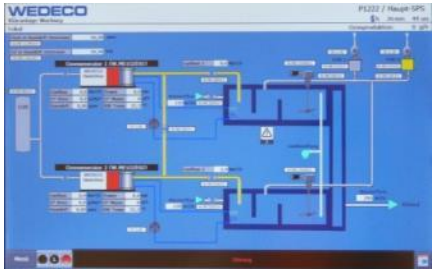
References

WWTP – Highlights

Xylem Complete Solution

Wedeco	**Ozone generator, COD, Instruments, PLC**
Sanitaire	**ceramic Dome diffusors**
WTW	**Multiparameter Online analyzer (COD, DOC, Nitrite, SAC)**



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Removal of Emerging Contaminants (EC) by ozone

- Costs -

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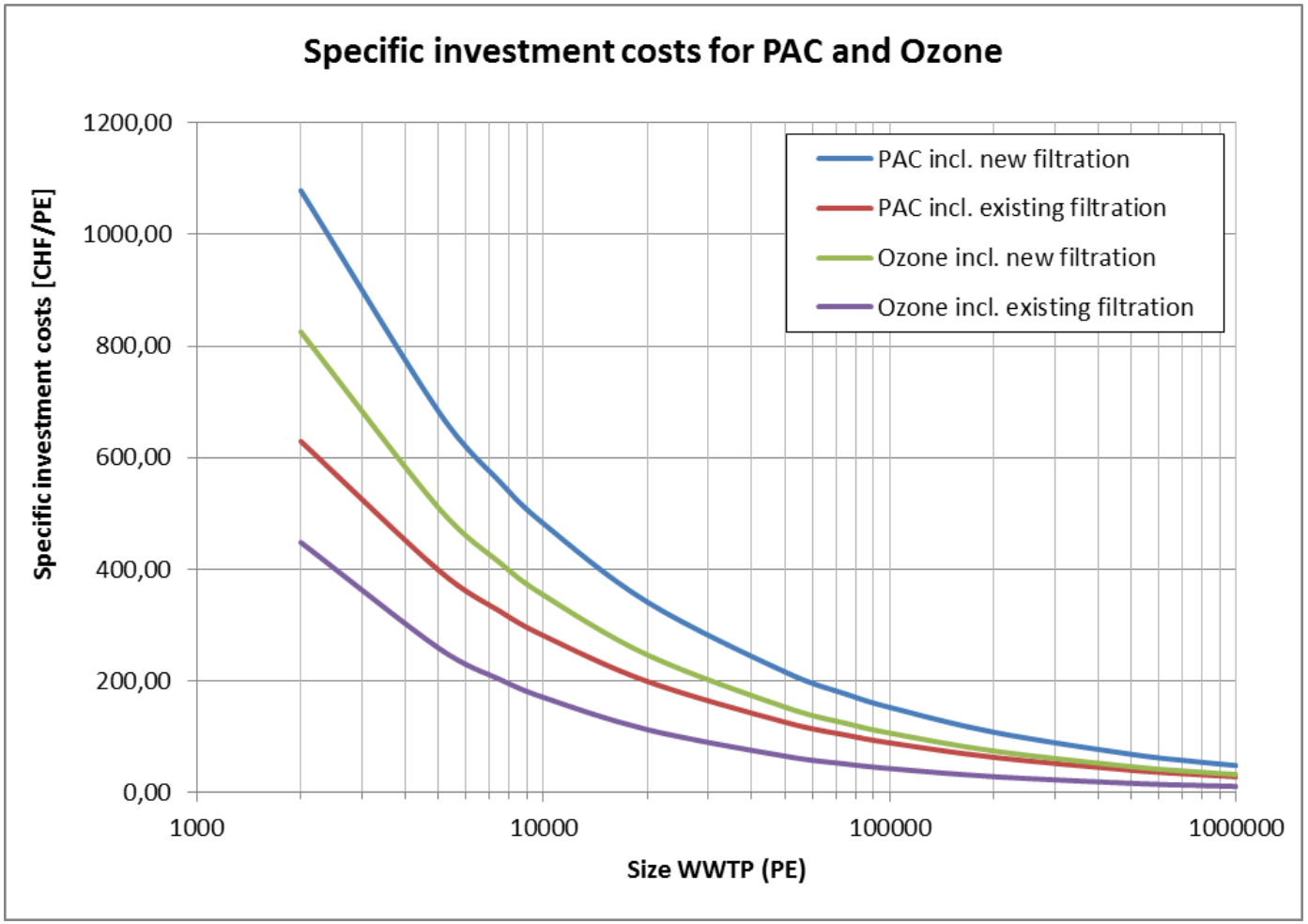
Costs for EC removal

Investment costs



Source: Summary from T. Haltmeier; Kosten der Elimination von Mikroverunreinigungen im Abwasser; 2012

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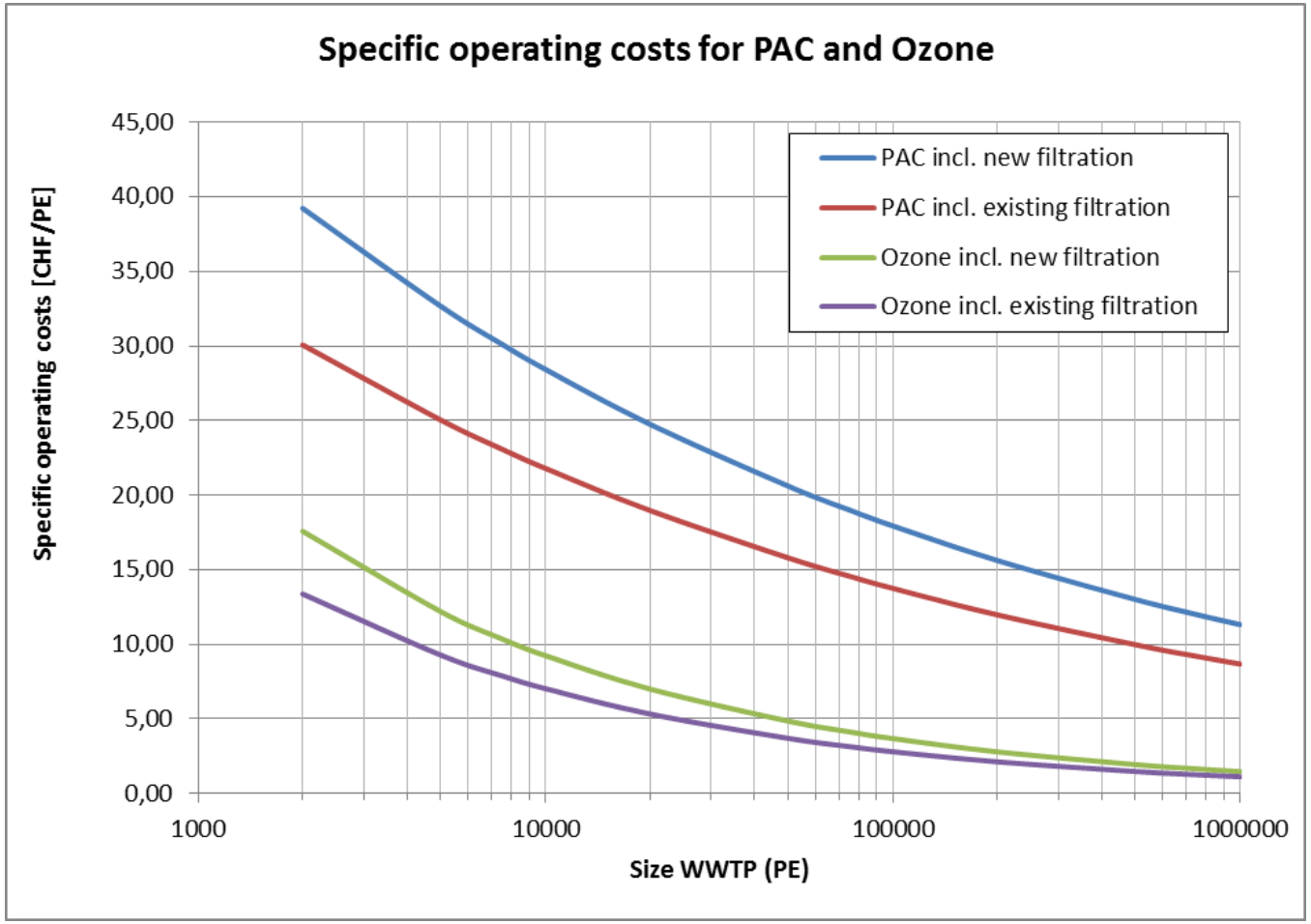
Costs for EC removal

Operating costs



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Removal of Emerging Contaminants (EC) by ozone

- Summary -

Summary

- Removal of EC‘s >90 %
- More versatile and less expensive than activated carbon (up to 40%)
- Low ozone dosages are required (approx. 0,6 - 0,8 g Ozone / g DOC)
- Simple implementation in existing and new projects
- Reliable and control supported process
- Low OpEx cost increase per m³ treated water: approx. 2 – 4 €uroCent

Thank you
for
your attention!

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