PRIORITY AND EMERGENT CONTAMINANTS IN MUNICIPAL WASTEWATERS: LEVELS AND REMOVAL IN CONVENTIONAL WWTPs

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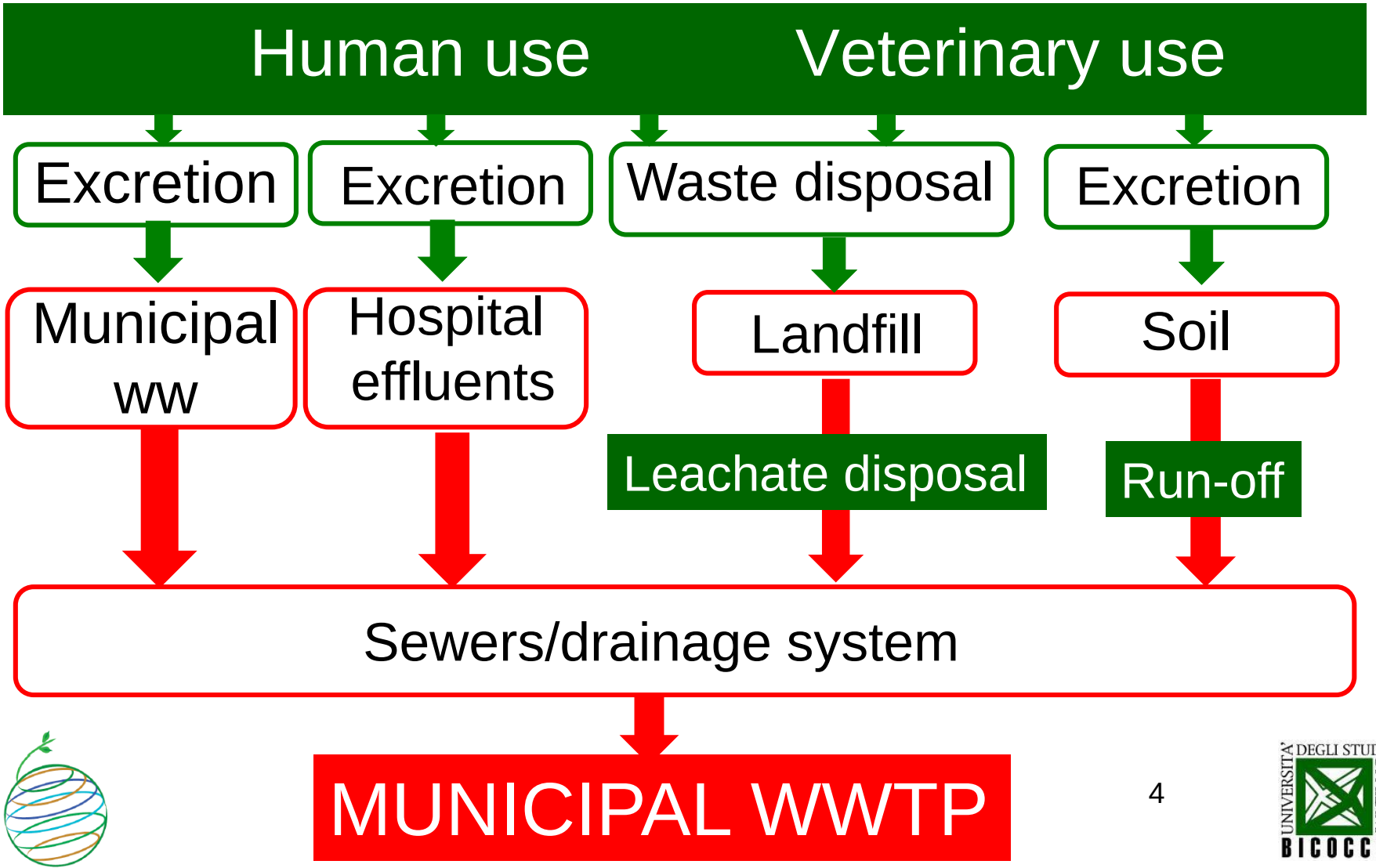
OUTLINE

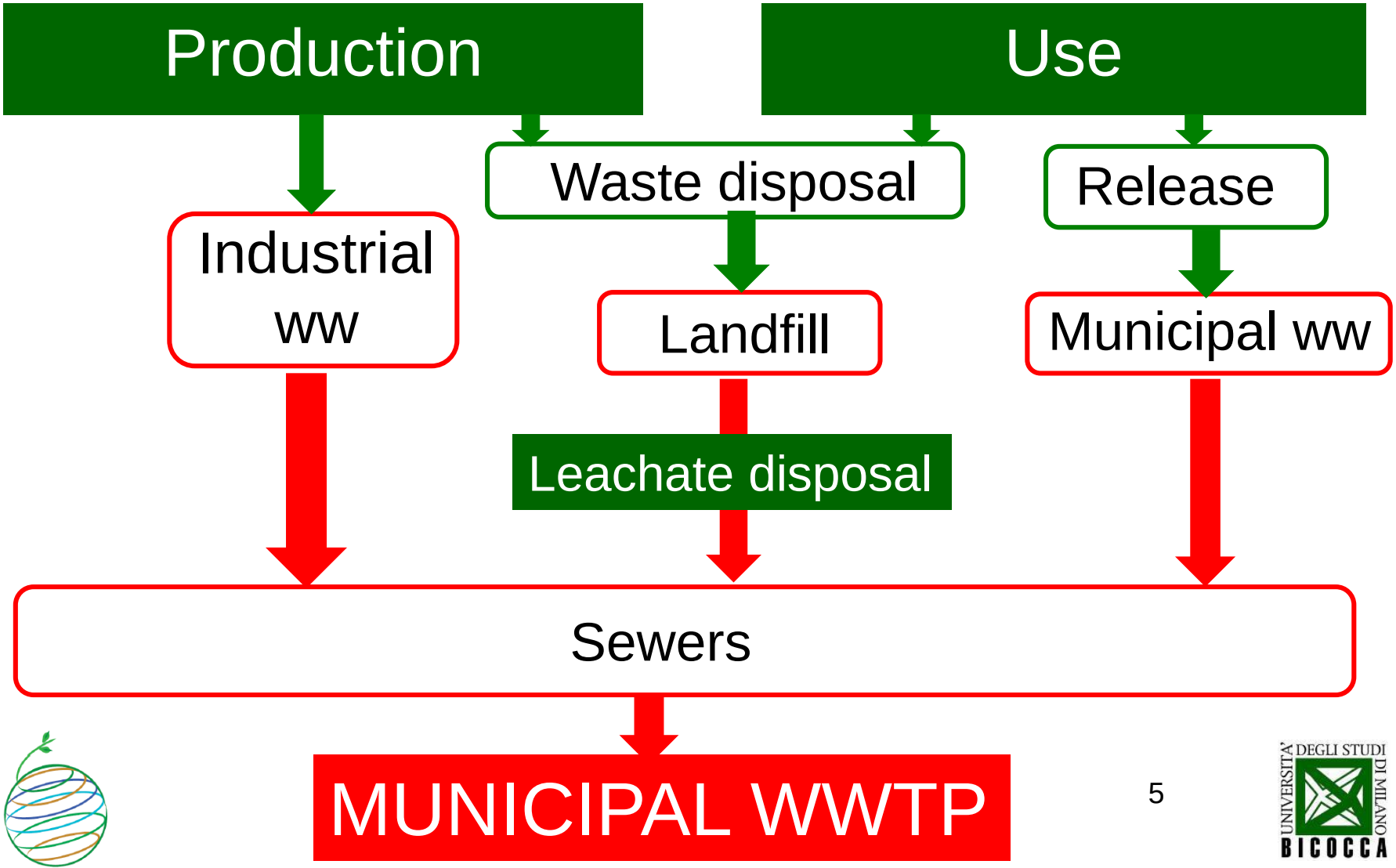
- Sources and concentrations in the influents
- Removal mechanisms
- Removal efficiencies
- Concentrations inthe effluents

SOURCES

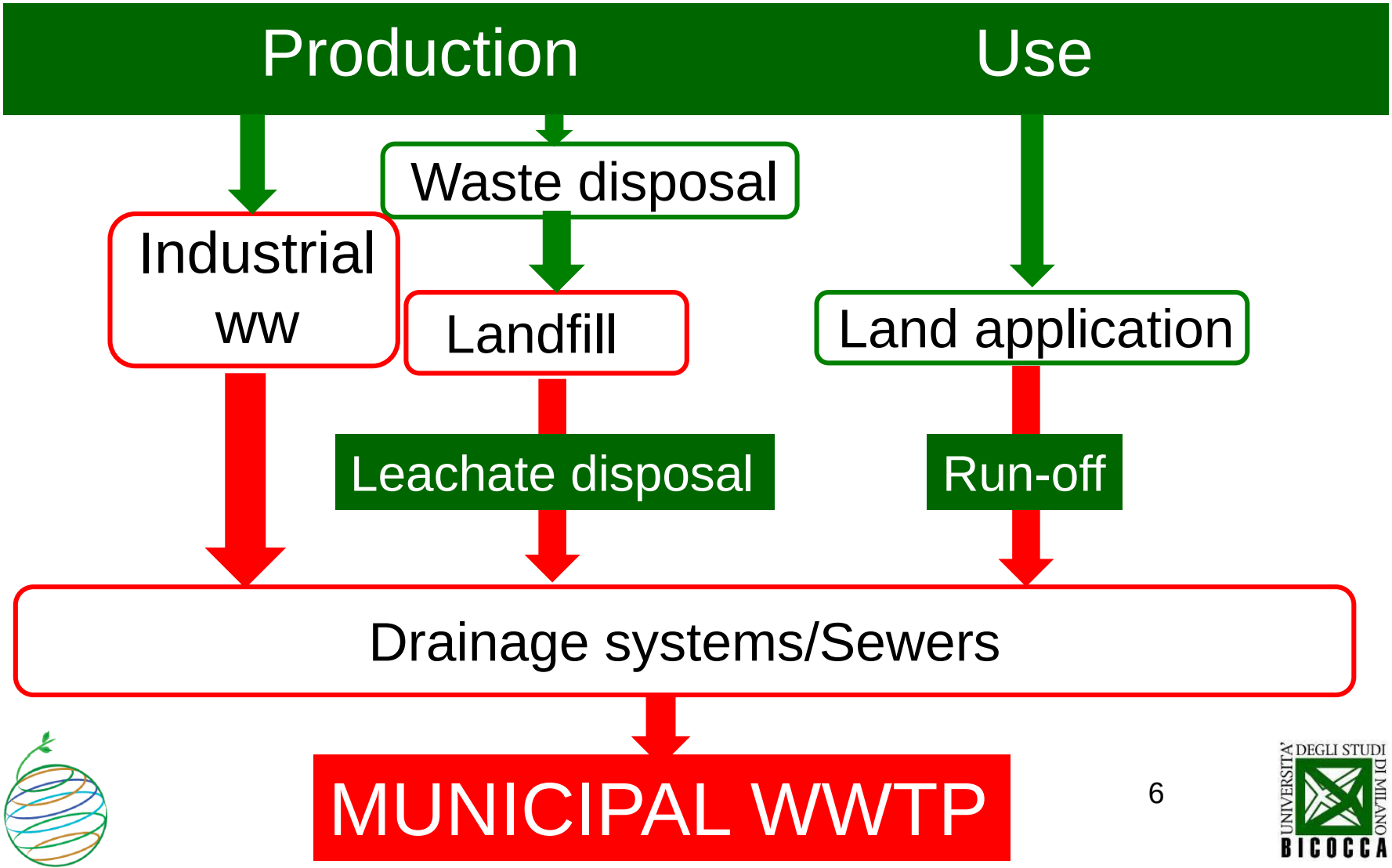
PREVAILING SOURCES FOR SPECIFIC MICROPOLLUTANT CLASSES: PHARMACEUTICAL COMPOUNDS



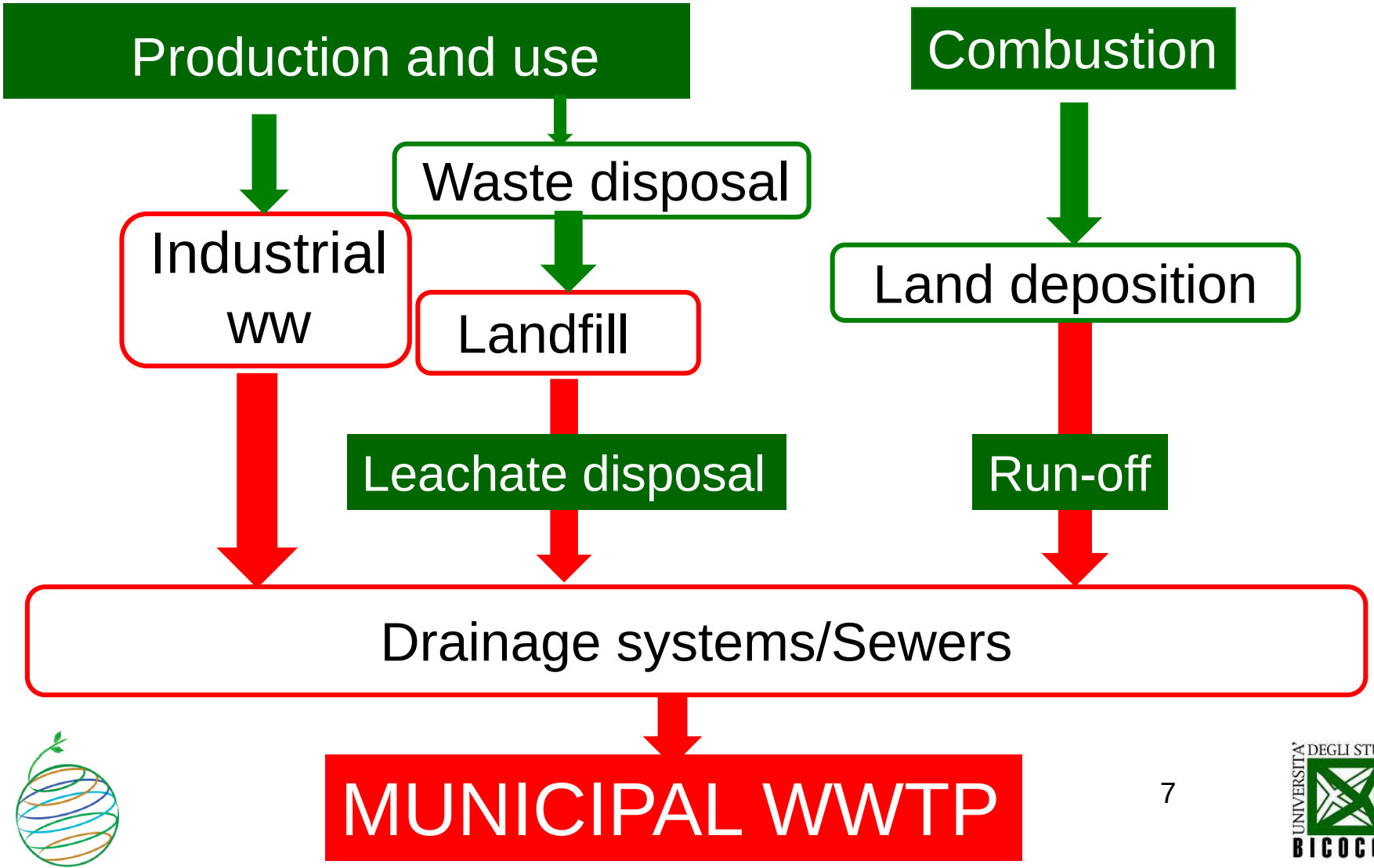
PREVAILING SOURCES FOR SPECIFIC MICROPOLLUTANT CLASSES: PFOA/PFAS, FLAME RETARDANTS, PCPs



PREVAILING SOURCES FOR SPECIFIC MICROPOLLUTANT CLASSES: PESTICIDES



PREVAILING SOURCES FOR SPECIFIC MICROPOLLUTANT CLASSES: PAH



CONCENTRATIONS

Significant time and space variations depending on:

- Local production and use/consumption (accessibility)
- Excretion rates (pharmaceuticals)
- Disposal ways (solid wastes, animal farming wastewaters)

CONCENTRATIONS: SOME EXAMPLES FROM INTERNATIONAL LITERATURE (Luo et al., 2014)

PHARMACEUTICALS	
Category	*Range (µg/L)*
Analgesic and antinflammatory	<0.001-603
Anticonvulsant	<0.04-3.78
Lipid regulator	0.05-1.39
Antibiotic	<0.003-17.1
B-blocker	0.002-33.1
Nervous stimulant	0.22-209

CONCENTRATIONS: SOME EXAMPLES FROM INTERNATIONAL LITERATURE (Luo et al., 2014)

PERSONAL CARE PRODUCTS (PCPs)	
Category	*Range (µg/L)*
Musk fragrance	<0.05-25
Disinfectant	0.03-23.9
Insect repellant	2.56-3.19
UV-filter	<0.079-0.90

CONCENTRATIONS: SOME EXAMPLES FROM INTERNATIONAL LITERATURE (Luo et al., 2014)

Category	*Range (µg/L)*
Steroid hormone	0.001-0.8
Surfactants	<0.03-101.6
INDUSTRIAL CHEMICALS	
Category	*Range (µg/L)*
Plasticizers	ND-70.0
Fire retardant	0.06-4.0

CONCENTRATIONS: SOME EXAMPLES FROM INTERNATIONAL LITERATURE (Luo et al., 2014)

PESTICIDES	
Category	*Range (µg/L)*
Herbicide	0.02-28.0
Insecticide	<0.684
Fungicide	ND-1.89

FACTORS AFFECTING THE TREATMENT PPLICABILITY AND EFFICIENCY

Molecular and physical-chemical properties:

- molecolar weight
- solubility
- volatility
- polarity
- adsorbability
- biodegradability

Treatment processes:

- **PHYSICAL**: by membranes, gravity, electric potential (electrodialysis), physical adsorbtion
- **CHEMICAL**: oxidation,chemiadsorbtion, ion exchange
- **BIOLOGICAL**: Biodegradation

CONVENTIONAL WWTPs

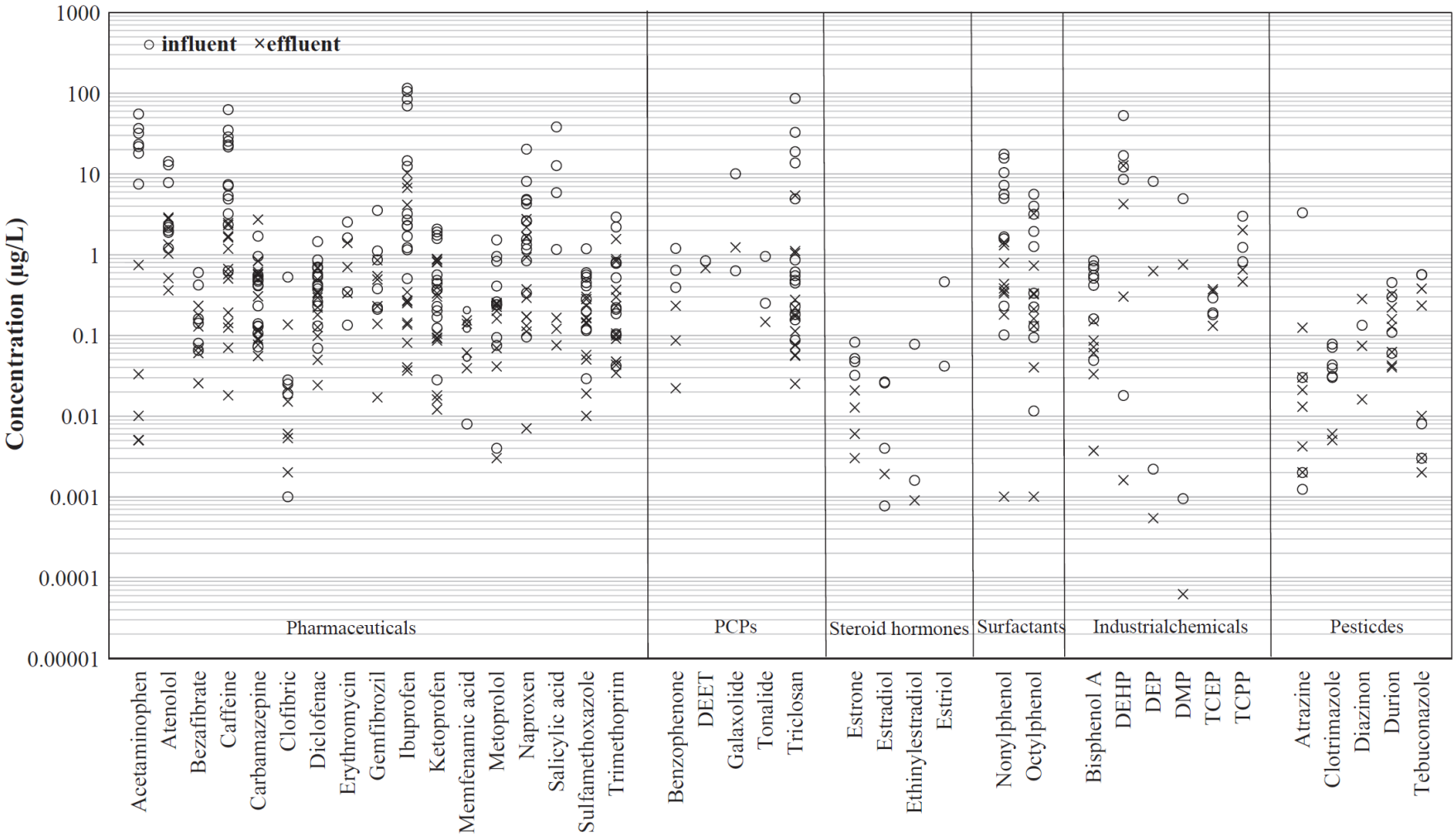
Suspended solids and gross materials	Organic matter and nitrogen	P, residual SS, microorganisms, PEPs
Mechanical treatments	Secondary treatment	Tertiary treatment and disinfection

Removal may occur by:

- biodegradation;
- Sludge adsorption;
- (stripping)

Removal may occur by:

- Flocculation/ precipitation
- Chemical oxidation
- Adsorbption
- Membrane filtration
- (Stripping)



Average concentrations (on logarithmic Y axis) reported for the selected micropollutants in WWPT influents and effluents

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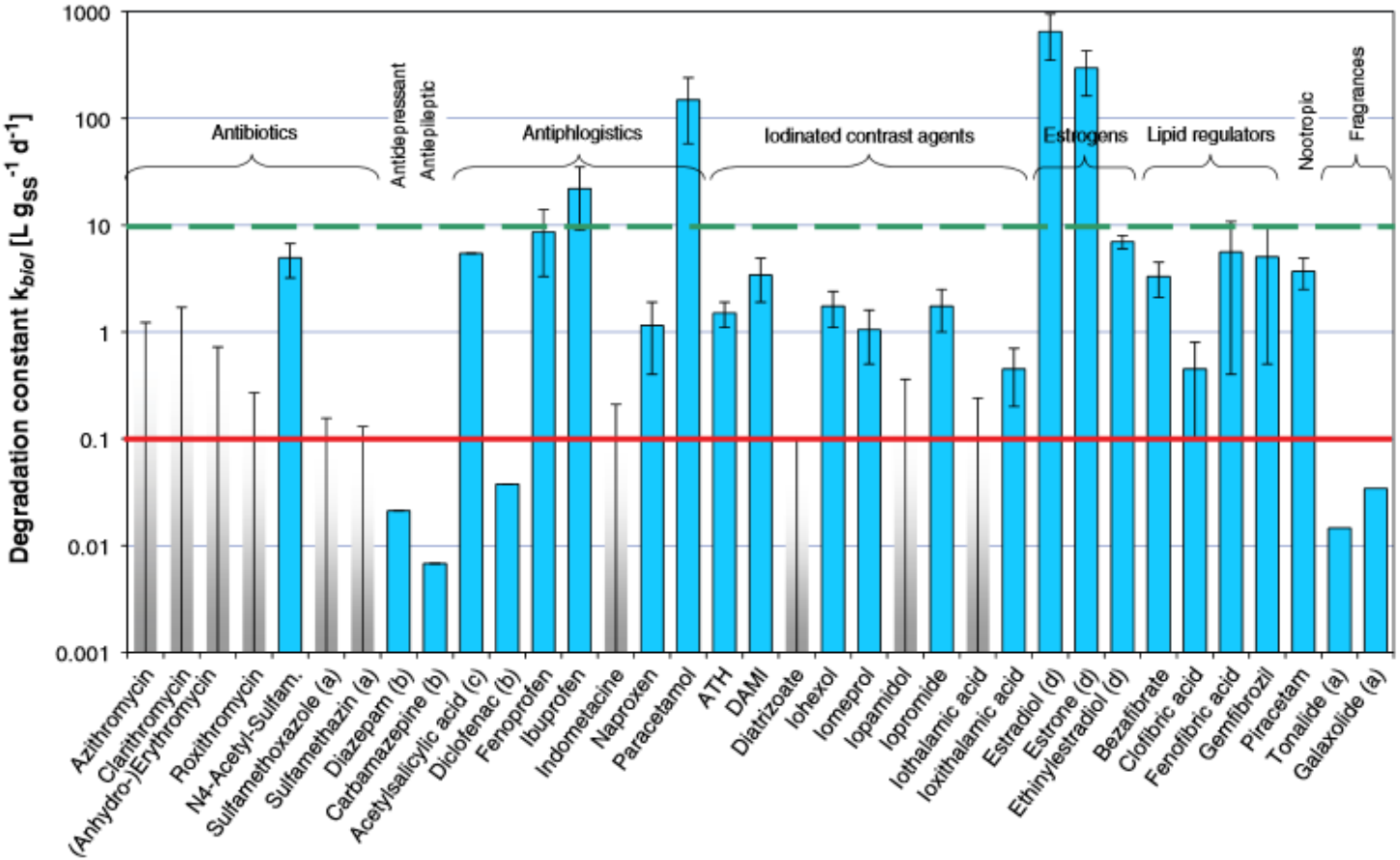
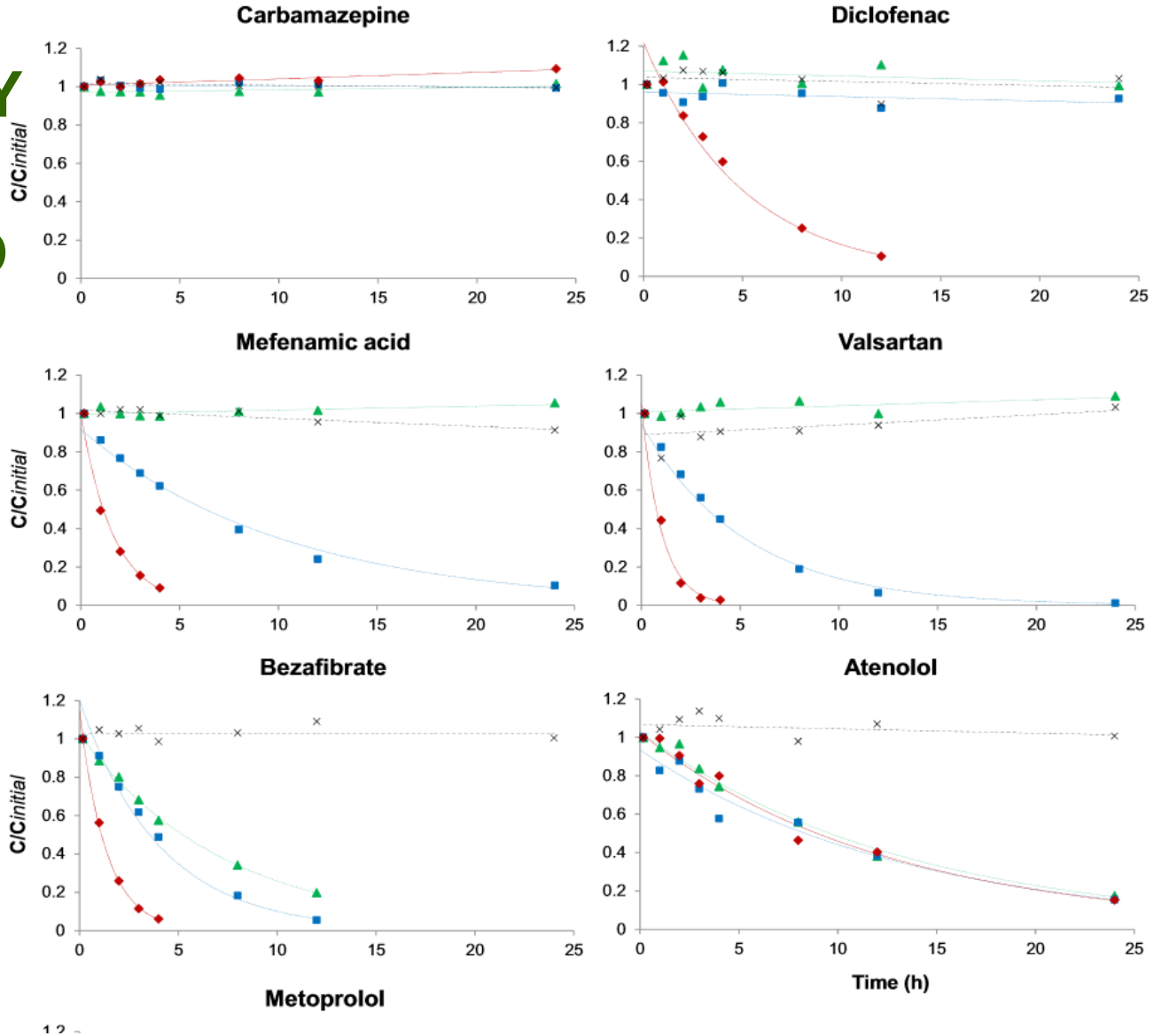
CLASSIFICATION OF BIODEGRADABILITY OF PHARMACEUTICALS (JOSS ET AL., 2008)



- K_{biol} < 0.1 L/g SS/d: no removal
- 0.1 < K_{biol} < 10 L/g SS/d: partial removal
- K_{biol} > 10 L/gSS/d: removal ≥ 90%

REMOVAL BY FIXED AND SUSPENDED BIOMASS



Falas et al, Wat.Res. (2013)

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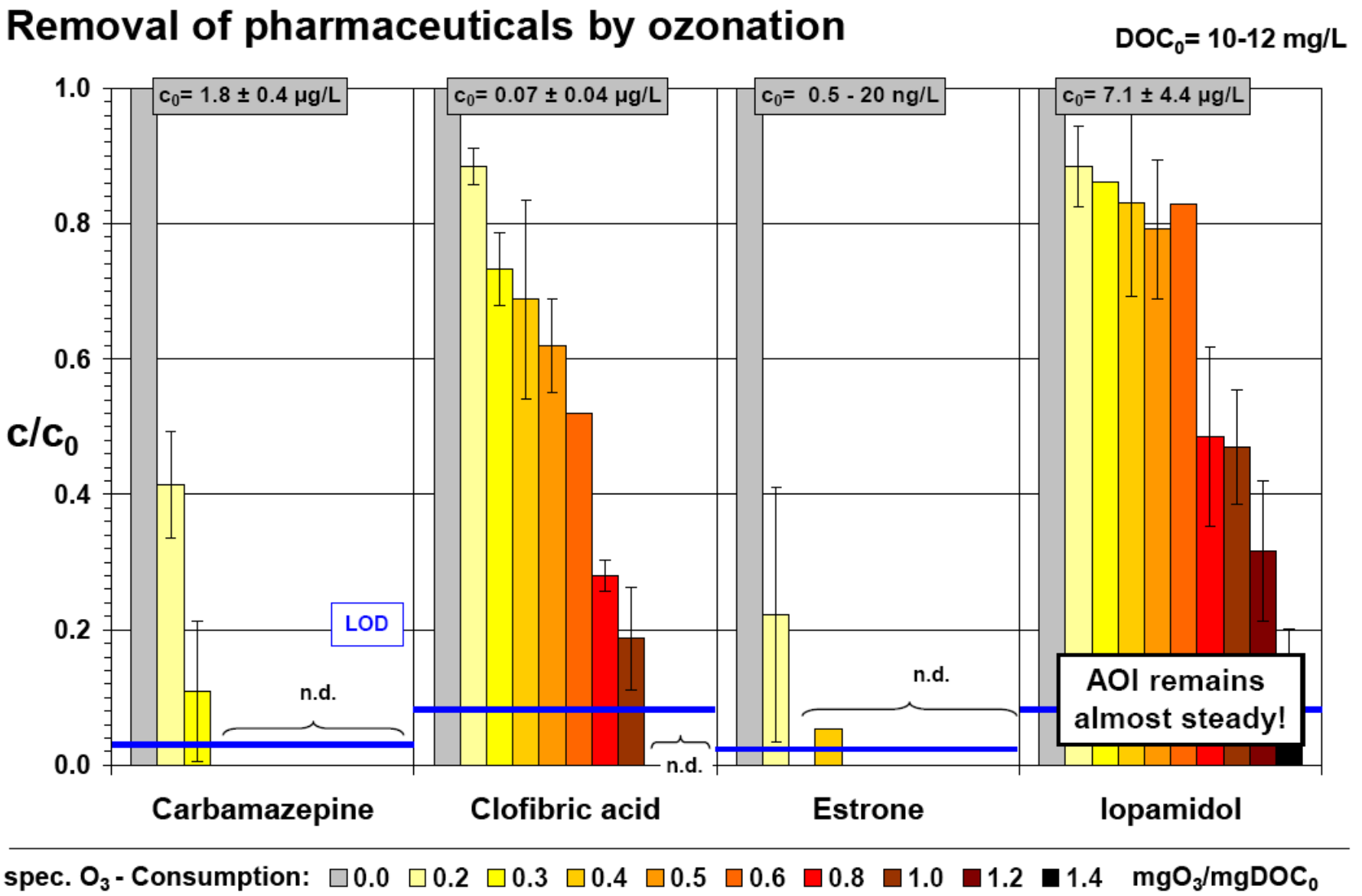
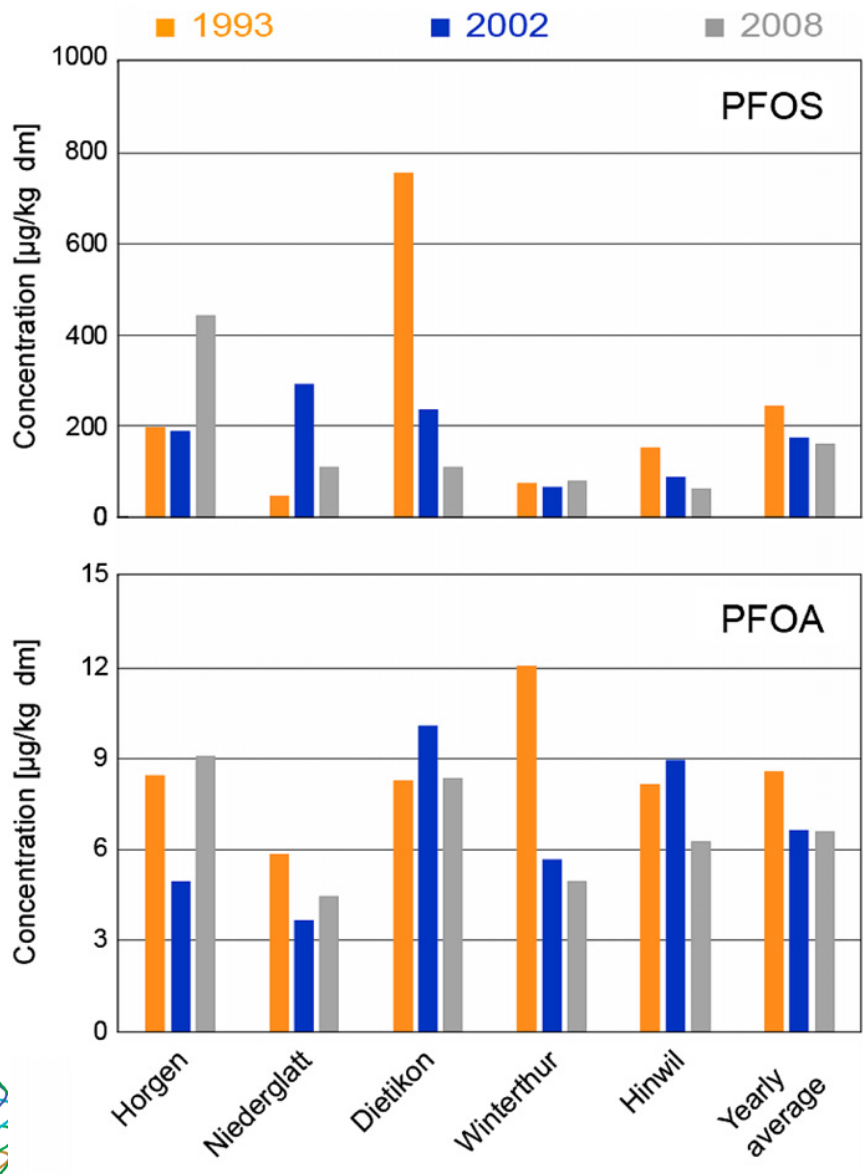
ADVANCED TREATMENTS: OZONATION
(Jekel, 2010)

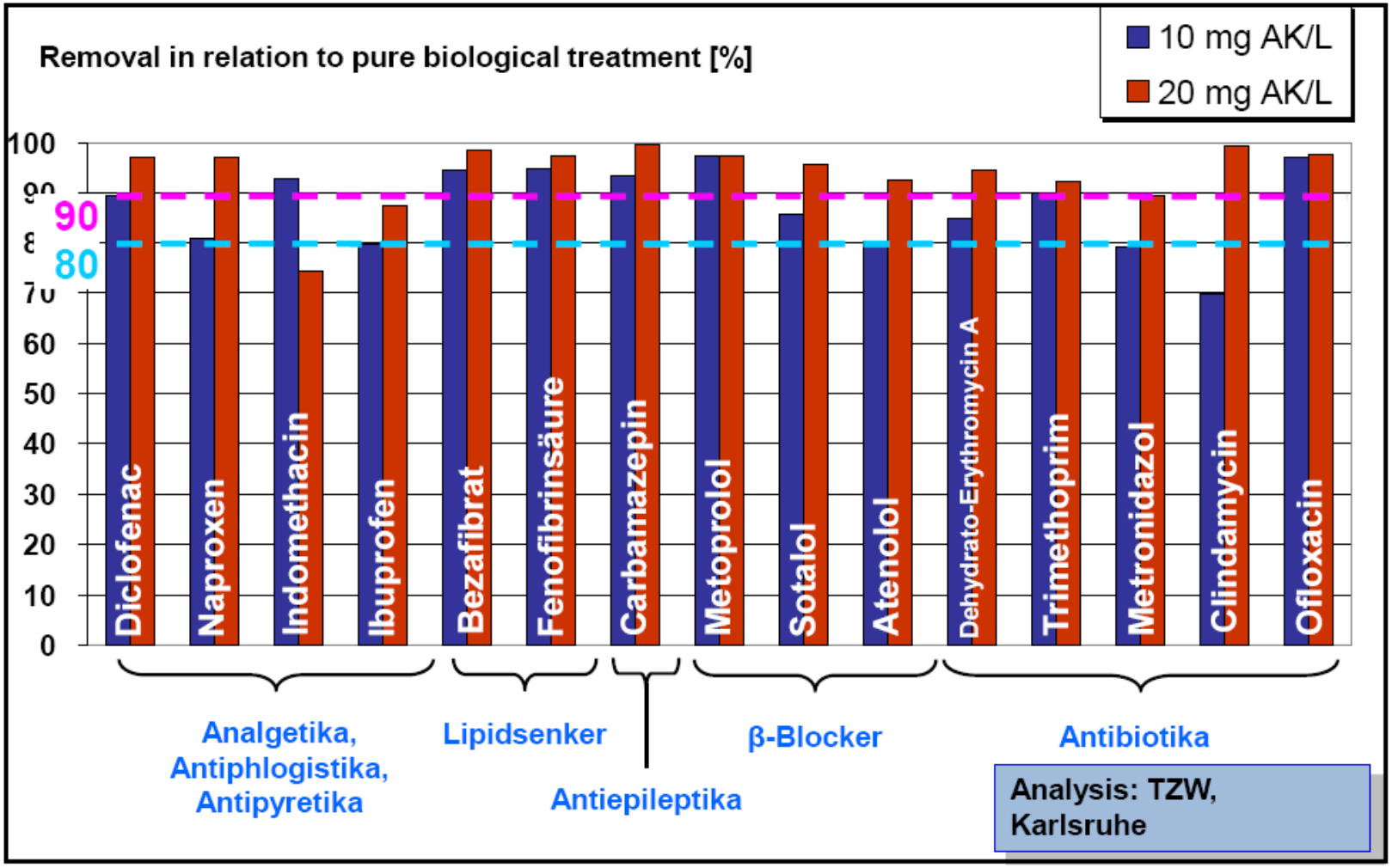


PFOS E PFOA: CAN BE ADSORBED BUT NOT BIODEGRADED



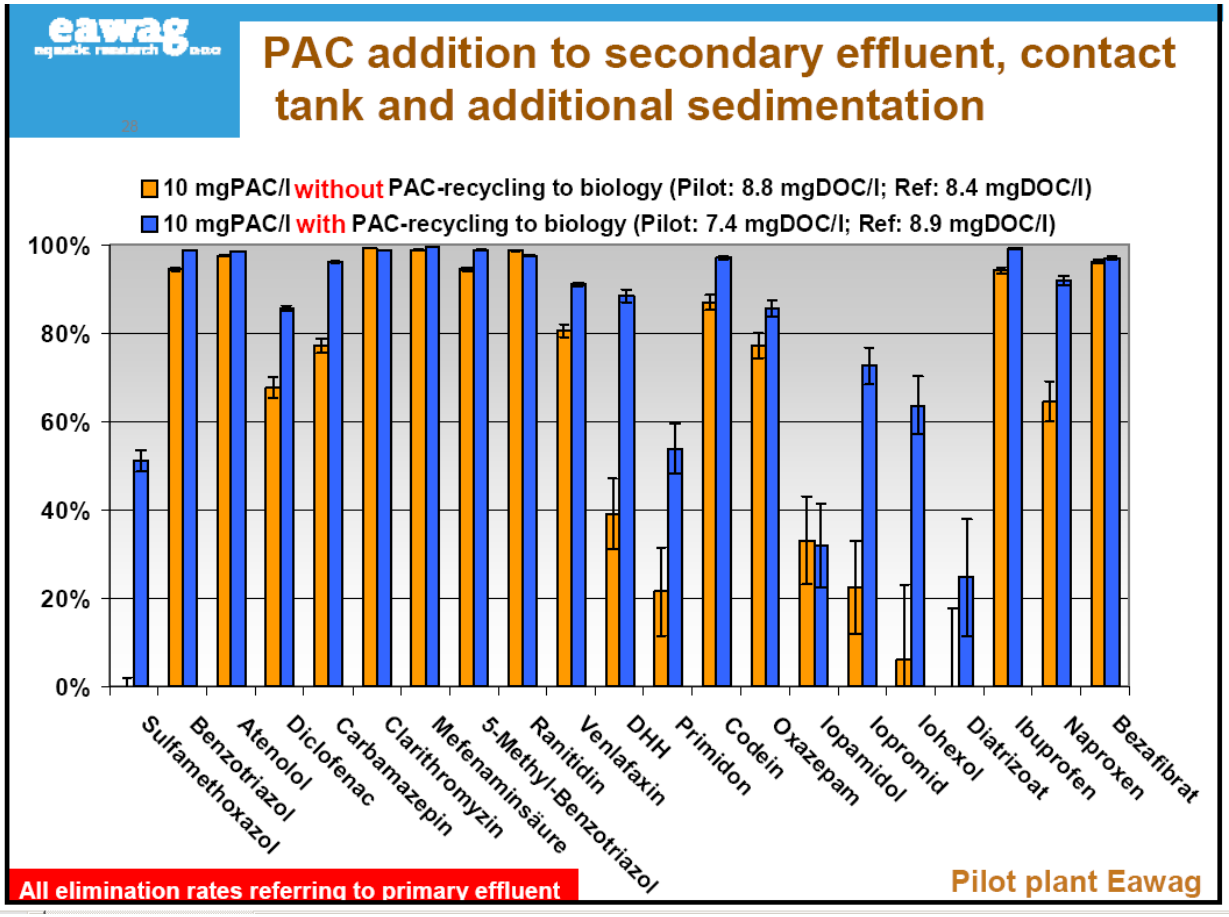
Concentration in sewage sludge (Sun et al., 2011 Env.Poll.)

POWDERED ACTIVATED CARBON (JEKEL, 2010)



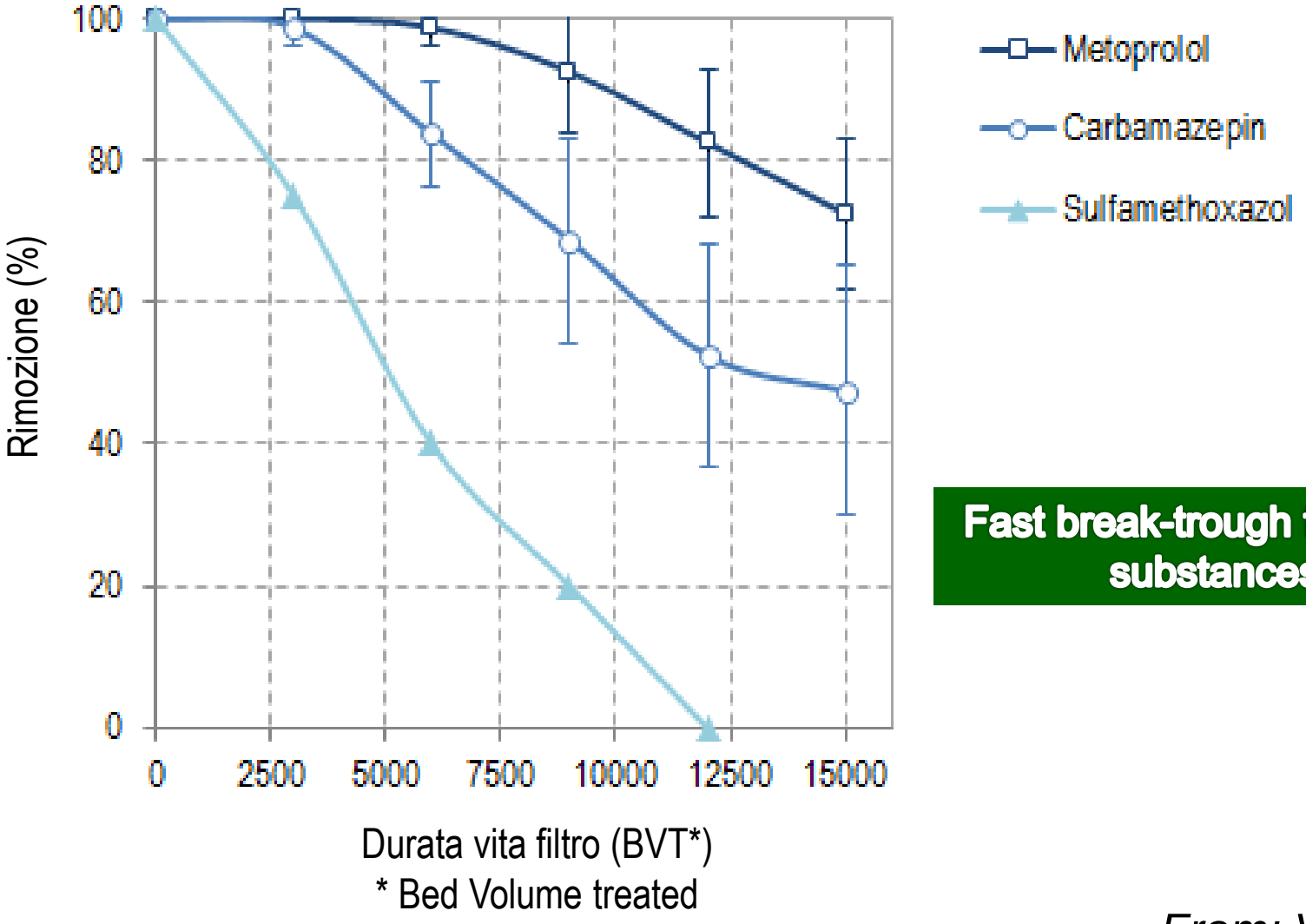
PAC added directly upflow final filtration.
Adsorption efficiency also related to dissolved organic carbon concentration

POWDERED ACTIVATED CARBON (SIEGRIST, 2010)



PAC added in tertiary treatment, with or without returning tertiary sludge to biological process

ADSORPTION ON GAC



Fast break-trough for some substances

From: VSA

MBR: RESULTS WITH DIFFERENT SRT: 15 vs. 35 vs. 50 DAYS

Similar removal for most substances.
However:

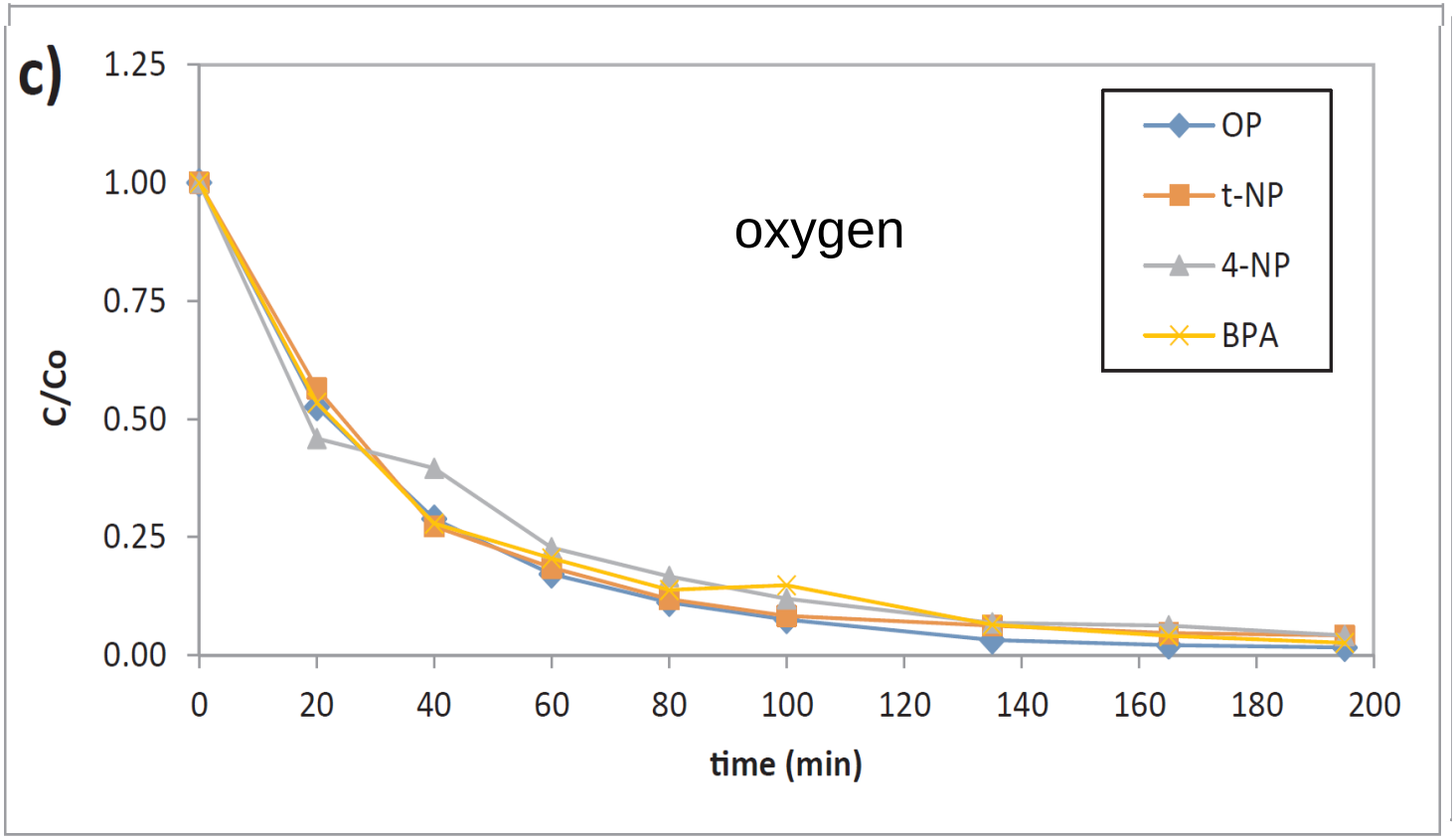
- **Diclofenac** and **Furosemide**: removal 15d<35d<50d
- **Atorvastatin**: removal 15d <35d
- **Ketoprofen** and **Ciprofloxacin**: removal 15d>35d>50d
- **Salbutamol**, **Ofloxacin** and **Demethyldiazepam**: removal 15d>35 d

MICROALGAE

Removal by:

- chemical oxidation,
- photooxidation
- Biodegradation
- Sorption

In algal culturing the conditions promote all such processes



OP = 4-tert-octylphenol, t-NP = technical-nonylphenol, 4-NP = 4-nonylphenol, BPA = bisphenol-A

Abargues et al., 2018

FINAL REMARKS

- Emerging pollutants reach sewers and WWTPs from a wide variety of sources and processes
- CSOs also contribute significantly to EP load to surface waters
- Different compounds behave differently behaviours towards treatments
- Removal efficiencies are case specific, with great variability depending on the properties of the compound, its starting concentration and the operative conditions of the WWTP.
- In general, conventional WWTPs without tertiary treatments are not able to ensure a sharp and, especially, a reliable and constant removal of emerging pollutants

OPEN QUESTIONS…

- Due to the differences among micropollutants and process efficiencies, reliable performances can just be obtained by combining different tertiary treatments
- With respect to treatment, micropollutats should be considerd not only for the category they belong but, especially, for their physical-chemical properties
- Considering the costs involved, interventions on the drainage systems and sewer overflows should also be considered
- The true need for advanced treatments should be evaluated with respect to the flow and conditions of the receiving waters
- …

THANK YOU FOR YOUR ATTENTION