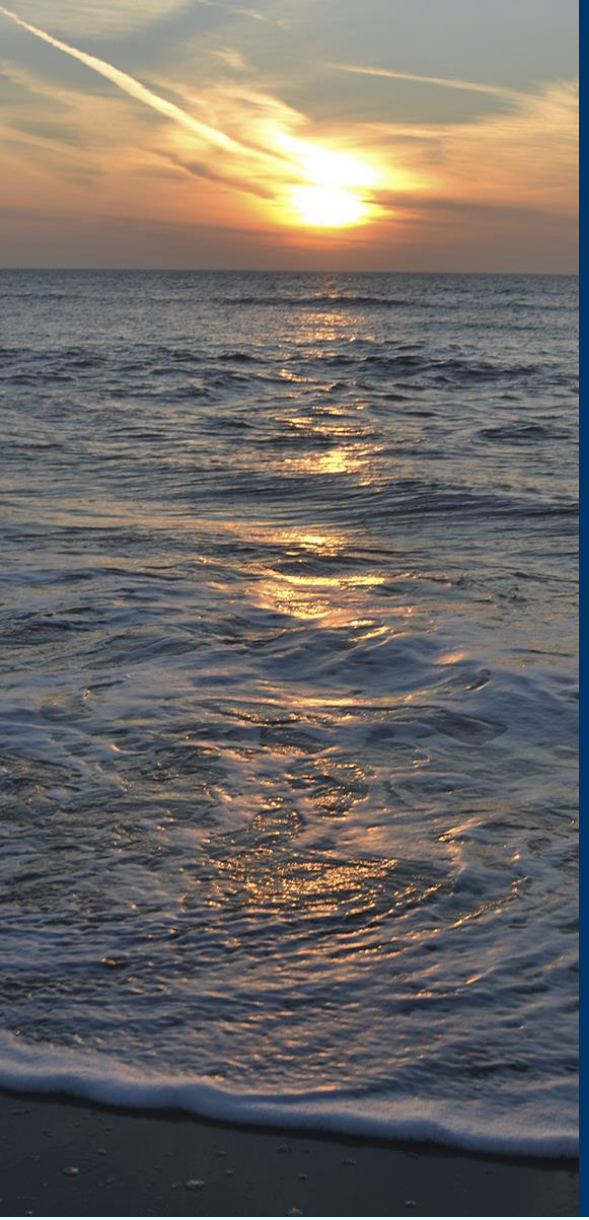

Organic Matter: new challenges on treatment processes

Literature and observers

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Observers

Questionnaire

- Drinking water treatment companies
- Waste disposal company

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Introduction

Challenges: OM fractions

- Variety of OM compounds
- Problems in treatment processes
- Variations in OM concentration and composition
- Different treatment steps

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Outline

CHARACTERISATION	• Of OM
PROBLEMS	• For different OM fractions
VARIATION	• In time and source
TREATMENT	• Overview of techniques

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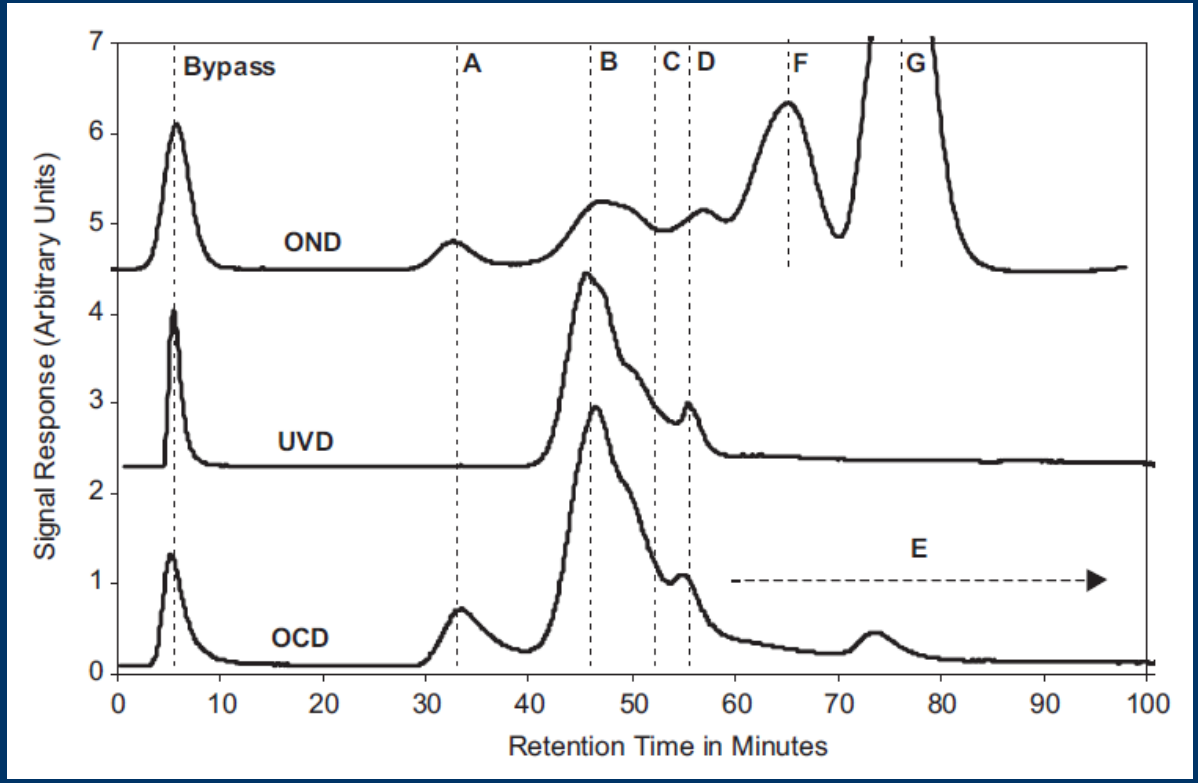
Characterisation

Fractions

- Hydrophobic/Hydrophilic
- Charge
- Size, UV absorbance, C and N content



LC-OCD-OND, example: Huber et al., 2011

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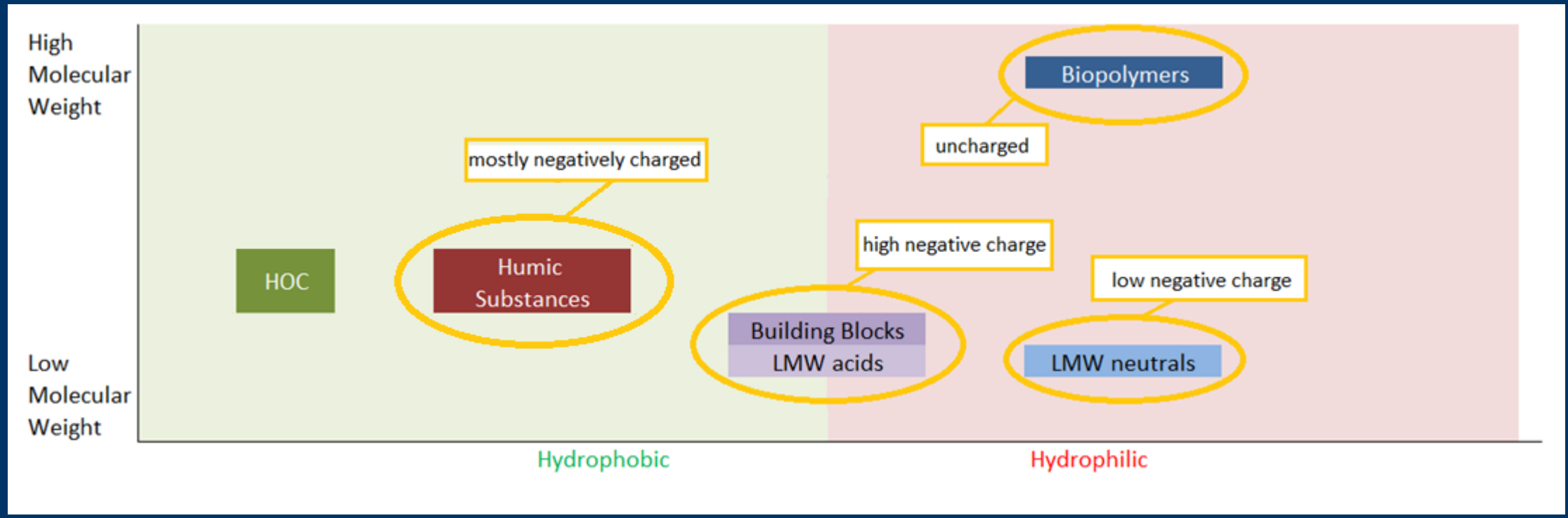
Characterisation

Fractions: Hydrophobicity, Charge, Size



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Characterisation

Hydrophobic OM

- Half or more of aquatic OM
- Detected by UV measurements
- Removed by coagulation

- Low Molecular Weight and Hydrophilic OM: difficult detection and removal

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Characterisation

Biodegradable and refractory OM

- Organisms: remove biodegradable OM or change its compositions

- Problems with fractionation:
  - Missing information on biological transformation
  - Low concentrations

- Biodegradable OM measurement
  - Biodegradable Dissolved Organic Carbon (BDOC): DOC consumption test
  - Assimilable Organic Carbon (AOC): biomass growth

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Characterisation

Origin

OM origin	Source
Allochthonous	• Vegetation, vegetative debris • Hydrology, geology, leaching
Autochthonous	• Algae: photosynthetic activity and decay • AOM, phytoplankton, macrophytes, excellular or intracellular OM, macromolecules, cell fragments
Effluent organic matter (EfOM)	• OM not removed during wastewater treatment • Soluble microbial products from biological treatment

Baghoth, 2012

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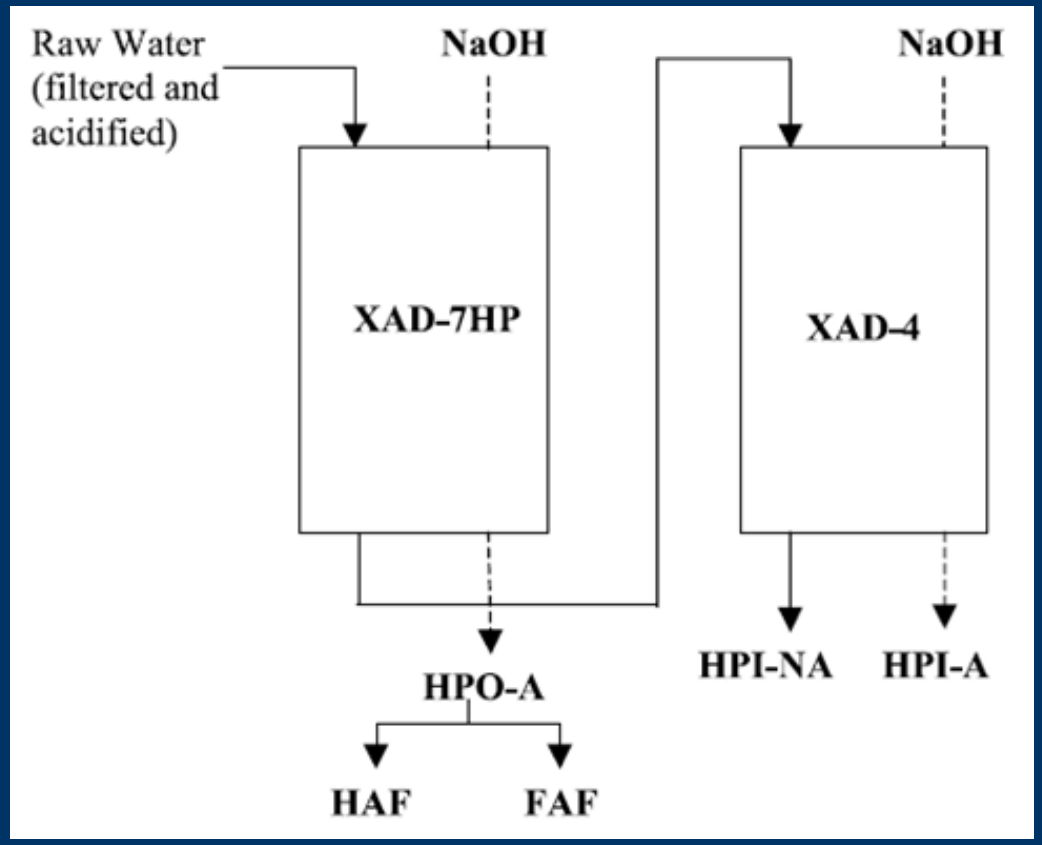
Characterisation

Observers: Measurements

- Total / Dissolved Organic Carbon (TOC / DOC)
- UV254, Color
- Disinfection By-Products:
  - Trihalomethanes (THMs)
  - Haloacetic Acids (HAAs)
- BDOC, AOC
- XAD resin fractionation



Sharp et al., 2006

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Characterisation

Observers: Measurements for specific research questions

- Dissolved Organic Nitrogen (DON)
- 3D Fluorescence (specific emission and excitation wave lengths)
- Size Exclusion Chromatography (e.g. LC-OCD)
- Molecule structure: Fourier transform ion cyclotron resonance mass spectrometry (FTICR-MS)

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Problems

Process

- Competition for adsorption surface
- Membrane fouling
- Biological instability
- Disinfection By-Products (DBPs)

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Problems

Competition for adsorption surface on Activated Carbon: OM and micropollutants

- Higher PAC dosage, frequent regeneration GAC

Problematic OM fraction	Cause
Lower Molecular Weight Hydrophobic	Adsorption competition on AC
Higher Molecular Weight Hydrophobic	Possible cause for pore blockage in GAC

Hu, 2006

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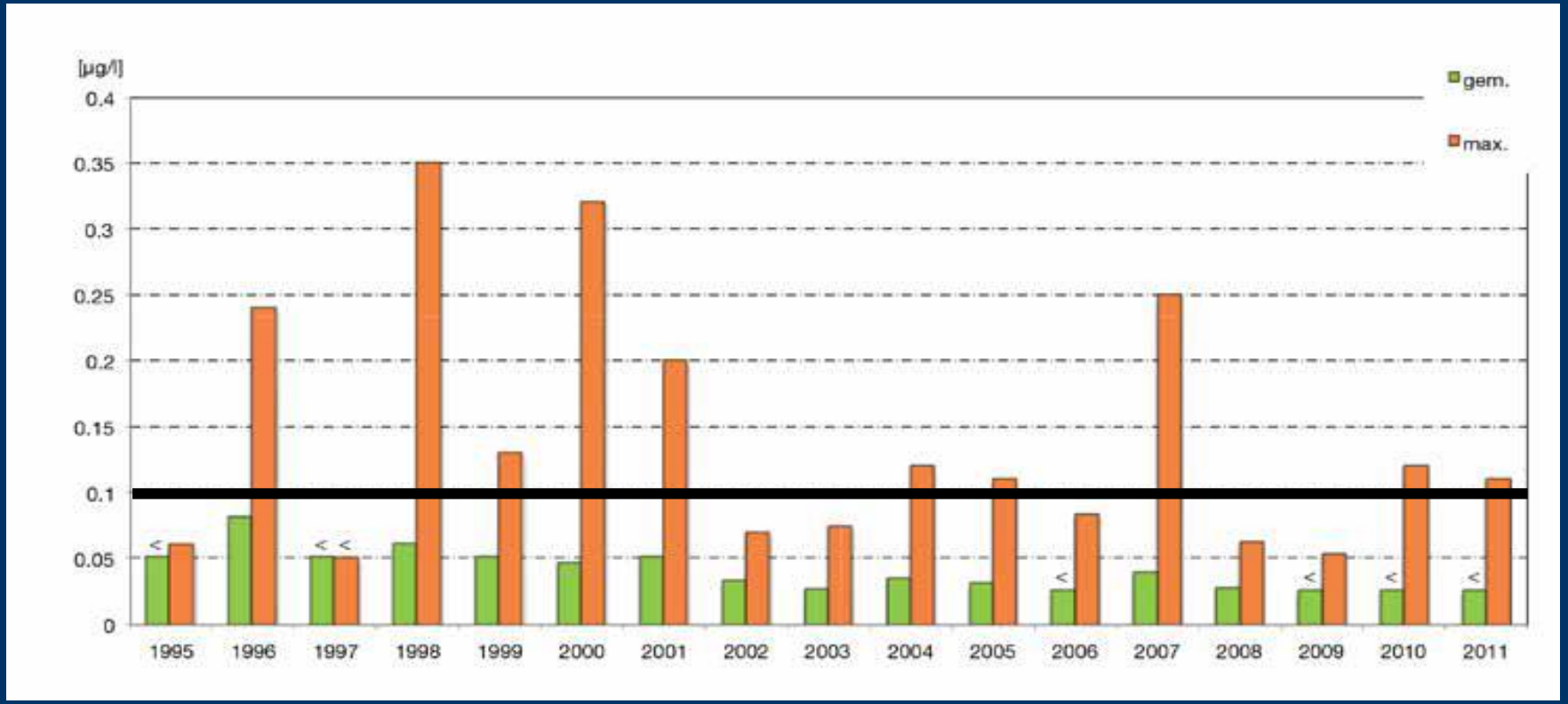
Problems

Adsorption competition on Activated Carbon: OM and micropollutants

- Example



Isoproturon (Rhine) and 98/83/EC
Adapted from ICBR, 2013

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Problems

Membrane Fouling

- Shorter lifetime, increase operational costs, permeability reduction

Problematic OM fraction	Cause
Hydrophobic	Association: irreversible fouling
High Molecular Weight, Hydrophilic (Biopolymers)	Association: reversible fouling

e.g. Metsämuuronen et al., 2018

- Operational parameters, types of membranes, raw water

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Problems

Biological instability

- Bacteria growth and biofilm formation

Problematic OM fraction	Cause
Hydrophilic	Major contributor biodegradable OM
Low Molecular Weight (<1kDa), Low Molecular Weight Acids	Mainly related to AOC
Humic Substances	Promote biofilm growth in distribution systems

e.g. Baghoth, 2012, Tran et al., 2015, Metsämuuronen et al., 2014

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Problems

Disinfection By-Products

Problematic OM fraction	Cause
High Molecular Weight, Hydrophobic	Main DBPs precursor (reactivity with Chlorine)
Hydrophilic	Main precursor of toxic bromated DBPs
Low Molecular Weight	Important contributor to DBPs

e.g. Metcalf et al., 2015, Matilainen and Sillanpää, 2010

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Problems

Disinfection By-Products: approaches

- Less disinfectant
- Change disinfection method
- Removal of OM precursors

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Problems

“If you're not part of the solution you're part of the precipitate”

- Some wise person

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Video

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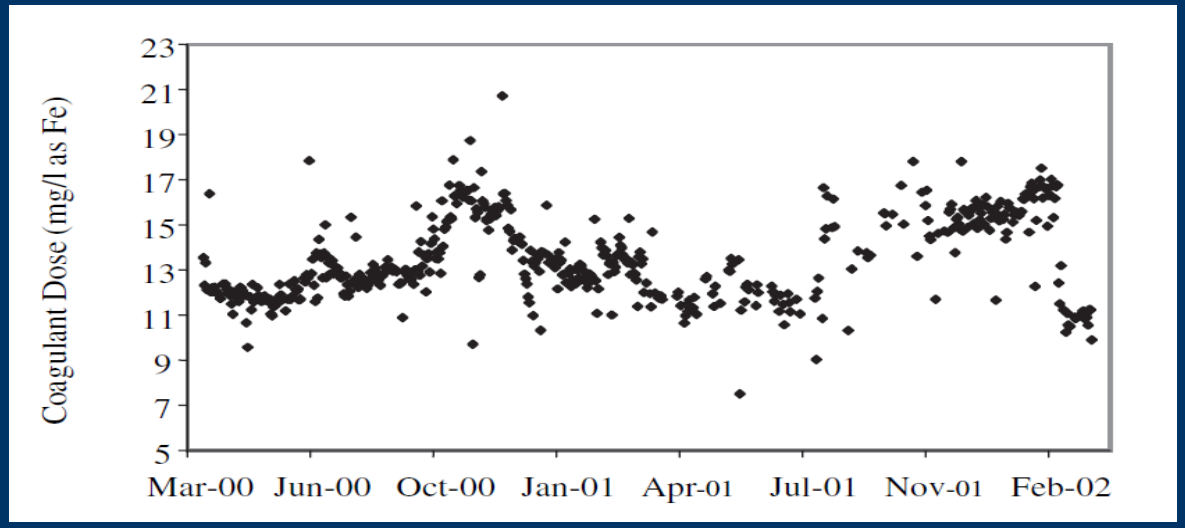
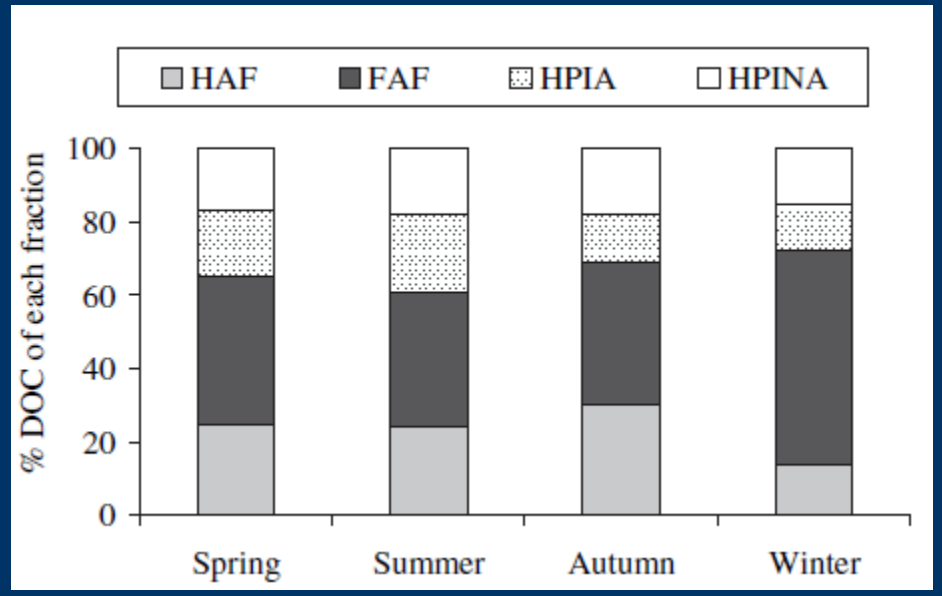
Variations

Seasonal changes

- Fractions (Jarvis et al., 2004), Charge density (Sharp et al., 2005)
- Operation of treatment plant





Jarvis et al., 2004

DOC removal:	81%	88%	75%	63%

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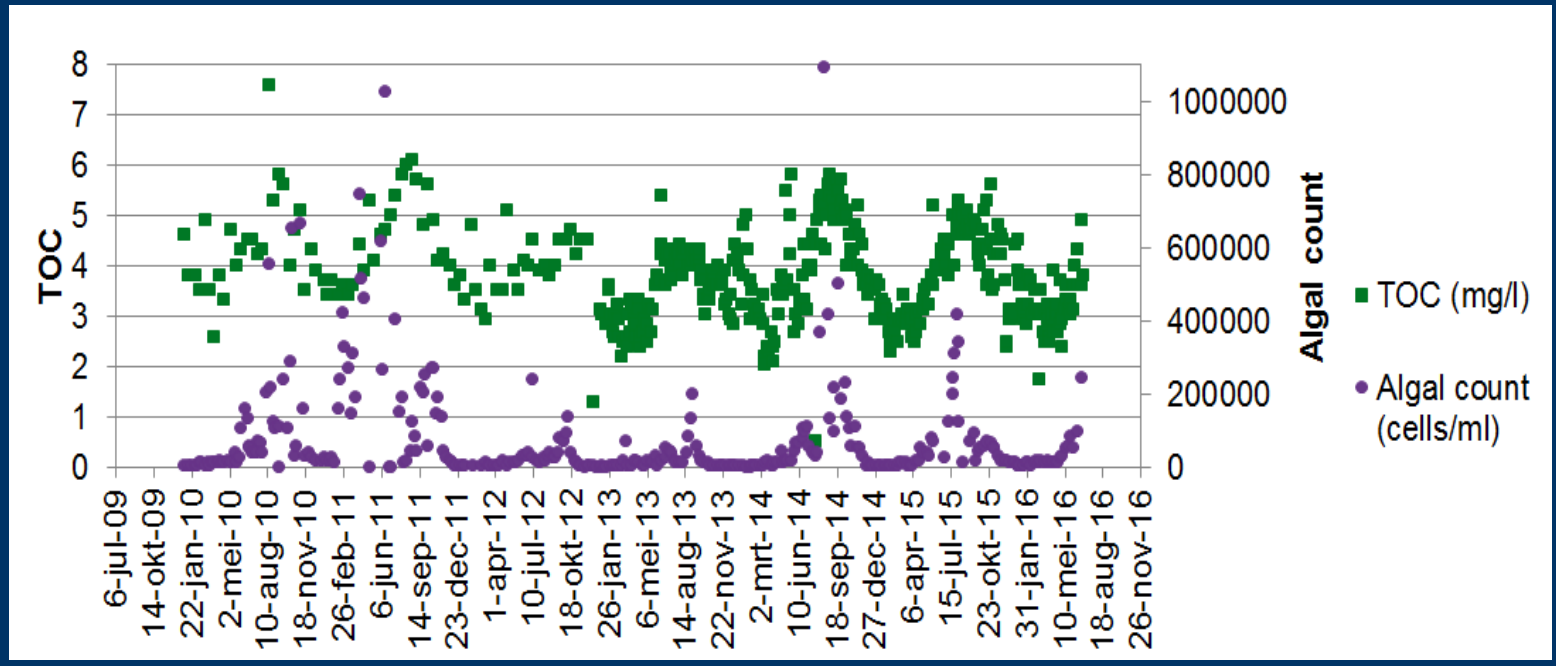
Variations

Seasonal changes

- Allochtonous OM, Autochtonous OM
- From observer:



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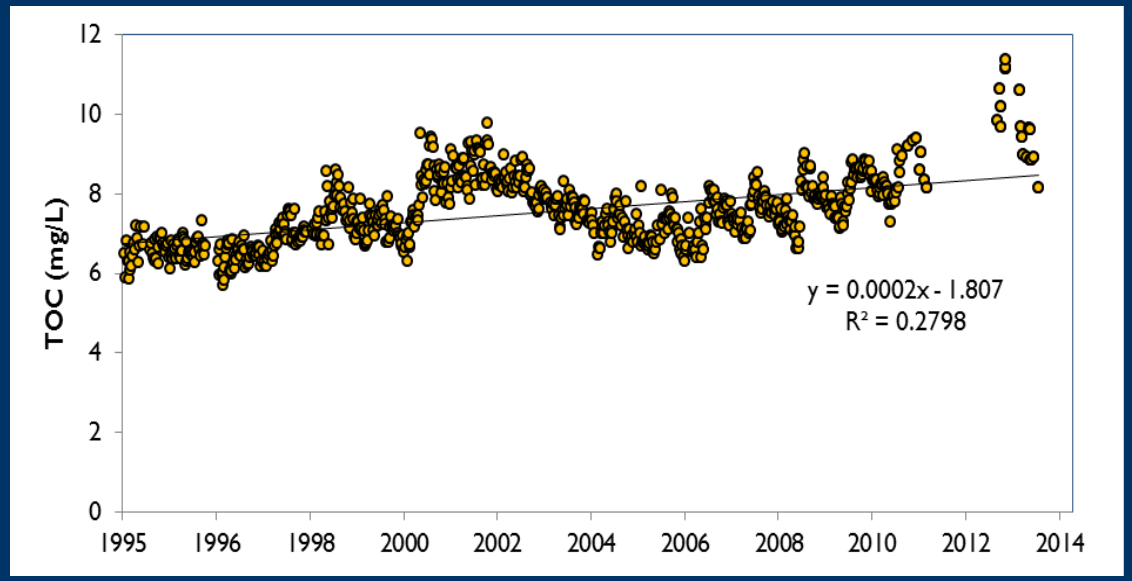
Variations

Long term trends

- 0.06-0.51 mg DOC/L/year in Northern Europe sites (Evans et al., 2005)
- Example 1, observer: lower quality water use by industry (high quality water scarcity)
- Example 2, observer:



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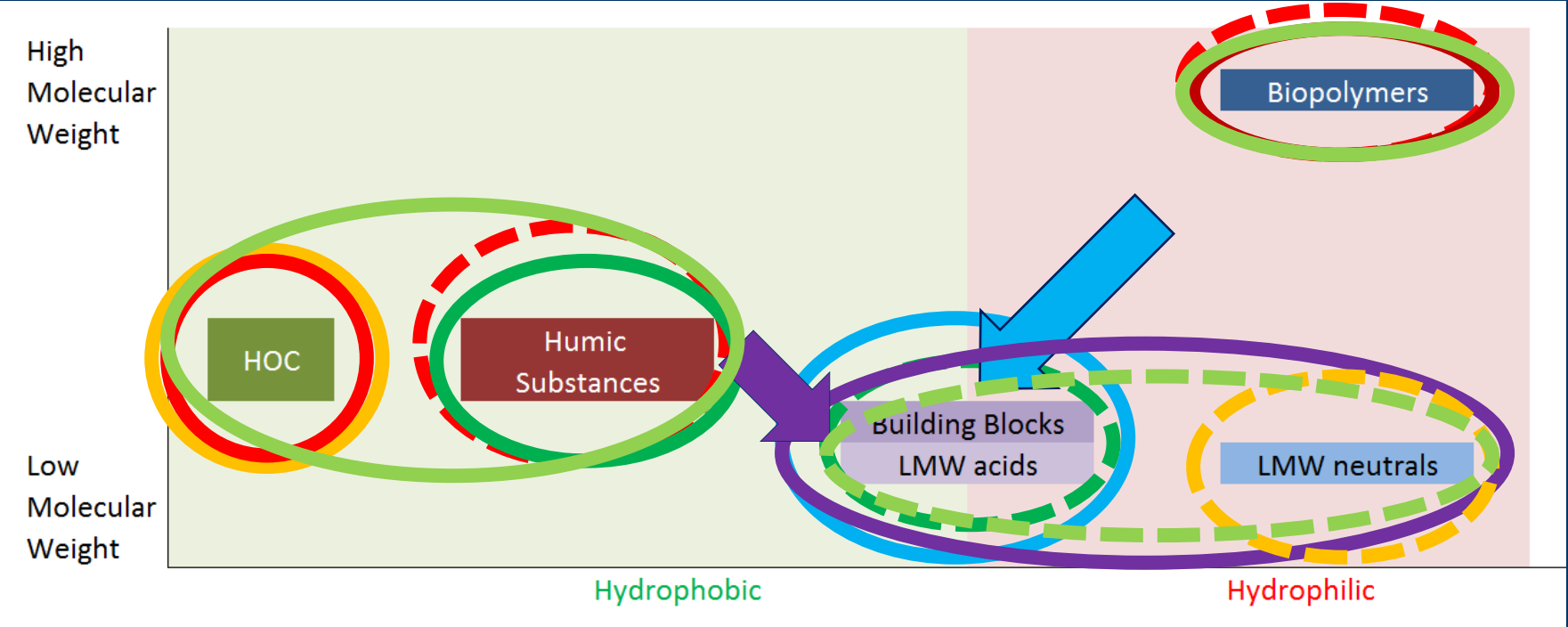
Treatment

Steps with different OM targets

- Coagulation:
- Ion Exchange:
- Managed Aquifer Recharge:
- Ozonation / Advanced oxidation:
- Activated Carbon:
- Ultrafiltration Nanofiltration



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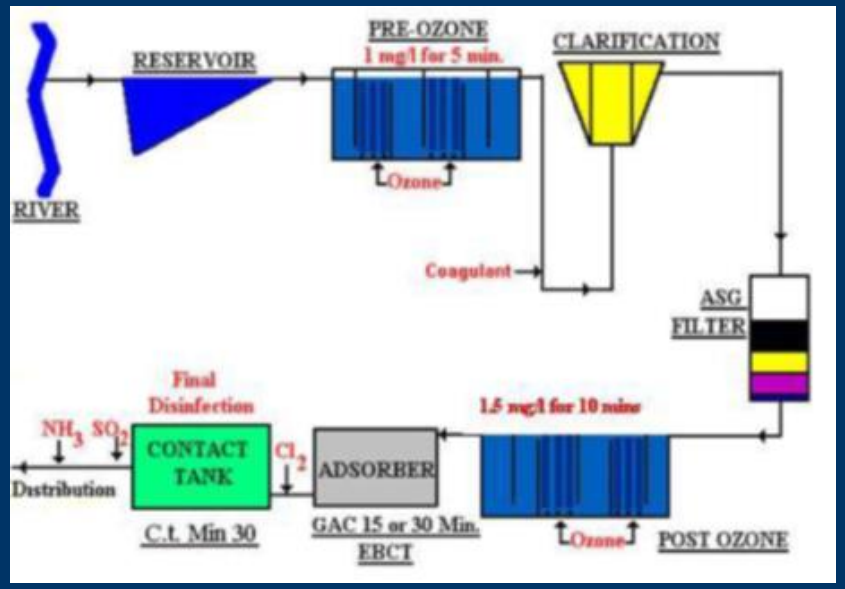
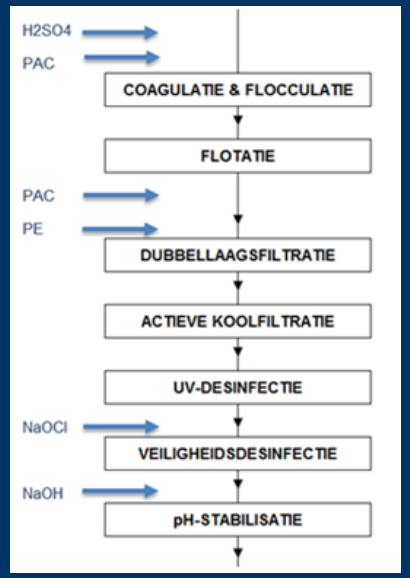
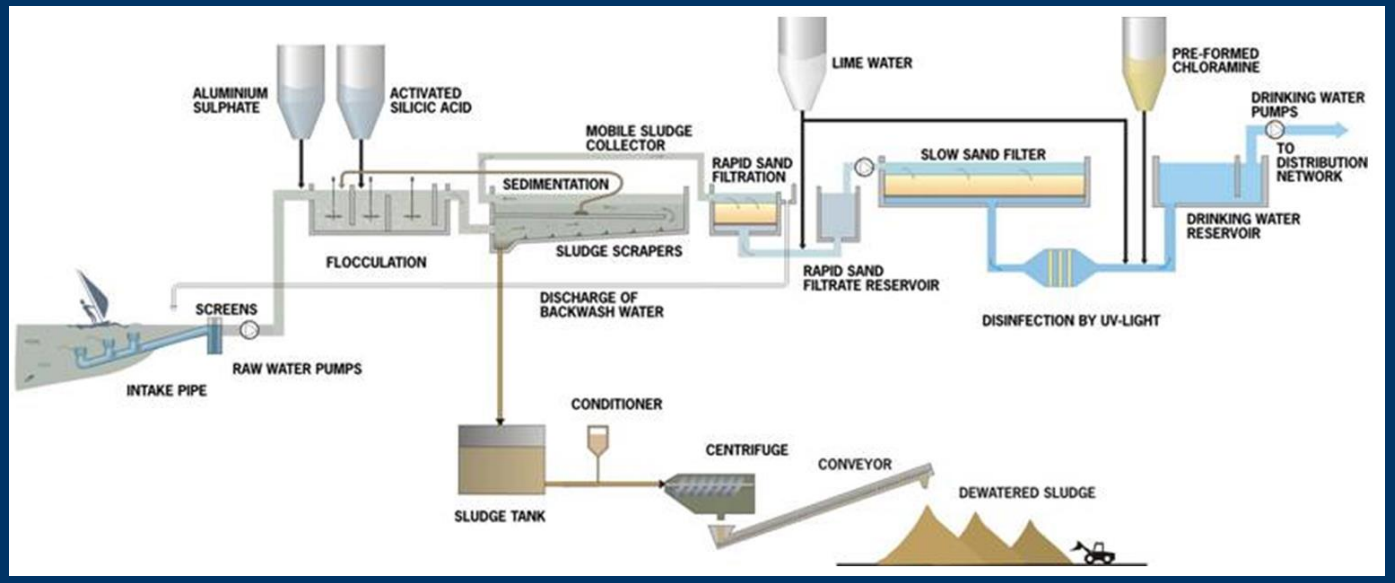
Treatment

Observers: current approach







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Treatment

Observers: current approach

- All presented schemes: conventional coagulation

- OM removal mostly side effect
- More focus on optimisation for low DBPs formation

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Treatment

Observers: motivations for changing approach

- Change of raw water quality (micro contaminants, DOC)
- Increase of LMW OM due to added oxidation step
- Increase of capacity
- High OM concentration in treated water

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Treatment

Observers: research optimisation and alternative technologies

- Ion Exchange (e.g. SIX, MIEX)
- Activated Carbon (e.g. reactivation rate increase)
- Ozonation
- Membrane filtration (e.g. Nanofiltration and CeraMac)

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Treatment

Observers: concern for Waste Disposal

- Interest in lower dependence of chemicals
- DOC removal: new residuals

- Residual DOC: a valuable material
  - Pure, high dry matter content, hygienic conditions

Figure from humicacidmanufacture.wordpress.com/

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Treatment

Observers: knowledge gaps

- Chlorine minimisation: influence of DOC and other parameters
- Impact of residual DON on DBP
- Enhancement of biostability
- Cost effectivity for DOC minimisation

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Conclusions

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Conclusions

Observers:

- Interest in strategies for DOC removal for the near future
- Changing quality of water
- Reduction of DBPs
- Waste disposal

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Conclusions

Incomplete knowledge:

- OM characterisation methods
- Impact of DOC and other parameters on DBP formation and biostability
- Available OM techniques and cost effectiveness

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Regional data

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Regional data

Data to include in the report

- Inflow / raw water source concentration of OM (variation range)
- Outflow concentration of OM (variation range)

- Measurement method OM (preference: DOC)
- Treatment schemes

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Thank you!

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