Application of a new online sensor for monitoring natural organic matter in drinking water treatment

AquaLife 2014, Kiel, 2014-06-03

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DVGW | TZW Technologiezentrum Wasser

Content

- Who we are… short introduction to TZW
- Natural organic matter (NOM)…
  - What it is
  - Importance for drinking water

Source: Harzwasserwerke GmbH

- Methods to analyze NOM
  - TZW method
  - Application Example

- Introduction of new device

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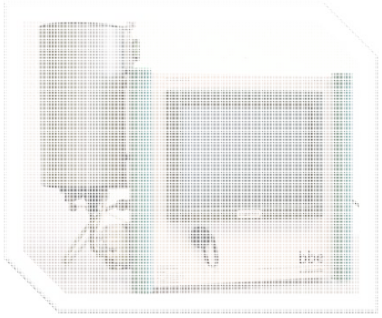

TZW: The German Water Centre

TZW

TZW: The German Water Centre

- Part of DVGW
- Transferring science into practice
- Applied research for the water sector:
  Expert reports and studies, testing services
- Branch offices at Dresden and Hamburg
- 150 full-time employees in total
- Funding
  - 35 % research projects
  - 65 % cooperation with water utilities

Quelle: bing

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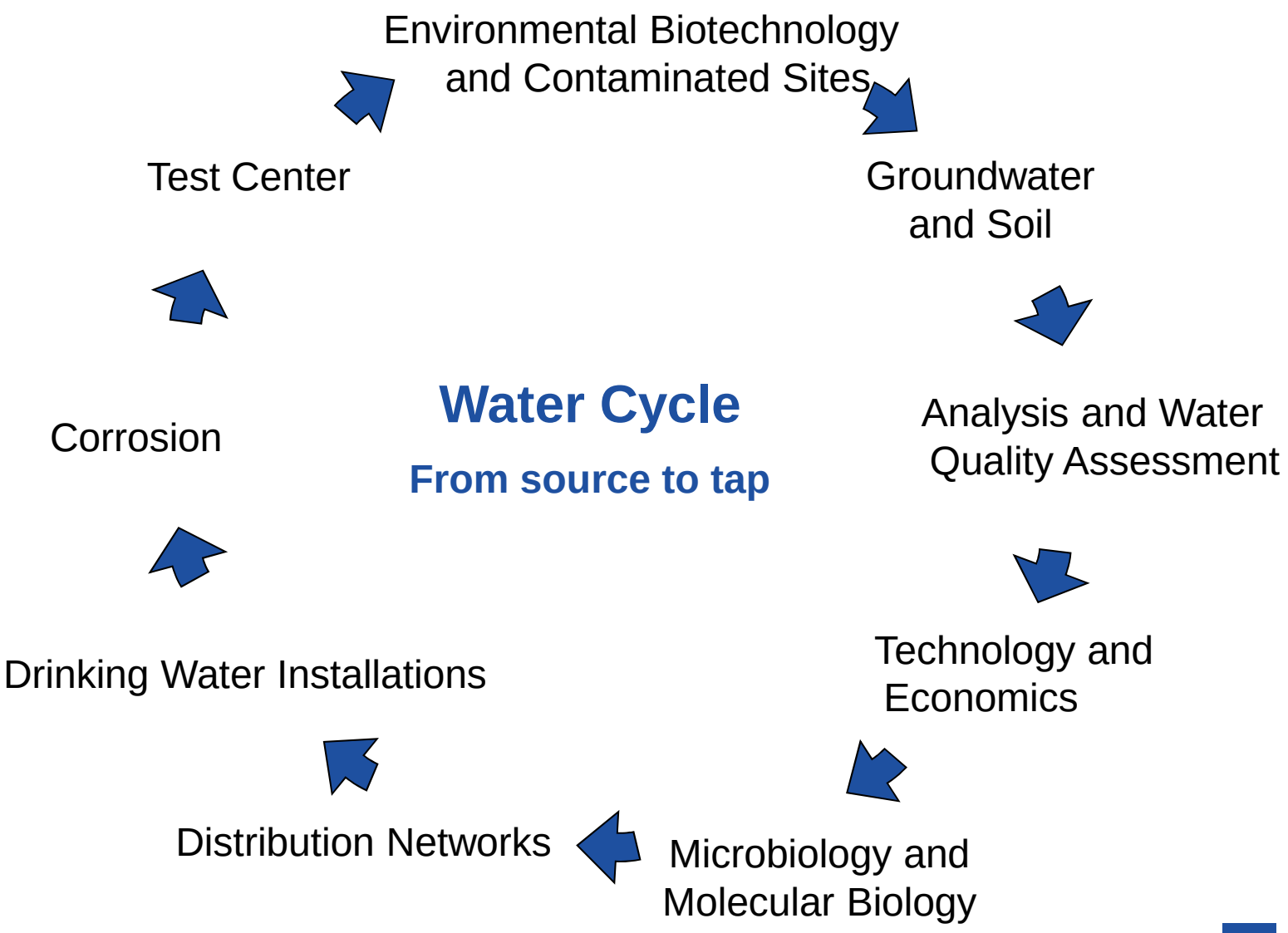
Areas of Work



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Chemical Analysis and Water Quality Assessment

- Determination of **water quality parameters** and **trace compounds**
- Fate and behaviour of organic micropollutants in aquatic systems
- **Monitoring programmes** for surface water, groundwater and drinking water
- Development and optimisation of analytical methods for water quality control
- **Water quality data evaluation** and reporting
- Assessment of findings as well as of organic substances in the water cycle
- Degradation and **transformation products**
- **Nanoparticles**

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Technology and Economics

- **Water processing**
  - **Concept studies**
  - **Process development**
  - **Optimization of operation**
  - Expertise
  - Dimensioning
  - Validation
- **Structural concepts**
  - Setup
  - Evaluation
  - Recommendation
- **Economic efficiency**
  - Cost determination
  - Comparison of options

- **Technologies**
  - UV instruments
  - Adsorption techniques
  - Membrane systems
  - Flocculation / Sedimentation / Filtration processes
  - Oxidation

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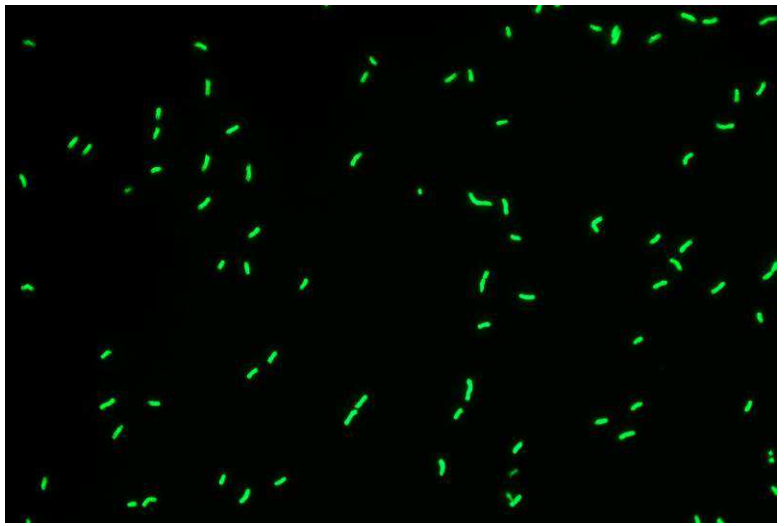
Microbiology

- Microbiological parameters according to the **Drinking Water Directive**
- Detection of bacteriophages
- Detection of pathogens (parasites, *Legionella*, *Pseud. aeruginosa, Campylobacter*,…)
- **Molecular biological methods** to identify bacteria
- Bacterial re-growth potential (AOC) of water samples
- Evaluation of microbiological contaminations of raw water
- Necessity of disinfection
- Change of disinfection methods
- Action plans when microbiological limits are exceeded



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International Activities and Projects

- BMBF
- Global Water Research Coalition (GWRC)
- CEN standardisation work
- DGENTR
- ACQUEAU
- IAWR, IAWD
- EUREAU
- Others

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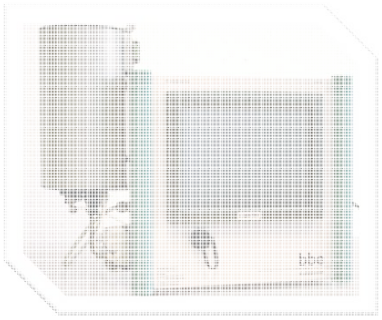

Natural Organic Matter

- some impressions

what we want: **clean drinking water**

water sample with algae

water sample with humic substances,
also called „**yellow substances**“

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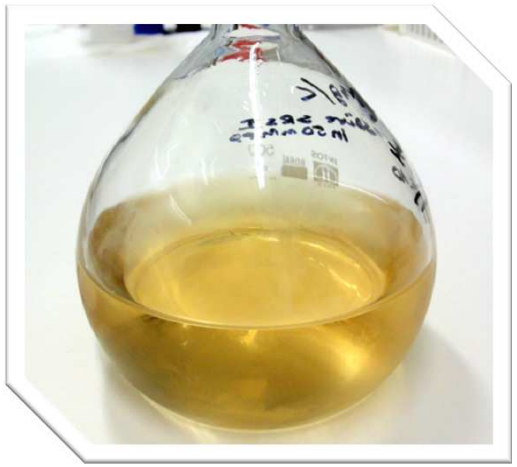
Natural organic matter

- **2 principal components**
  - **Non humic substances:** biologically easy to degradate (BDOC, AOC)
    - Proteins, amino acids
    - fats, carbohydrates, polysaccharides
    - Low molecular acids

  - **Humic substances:** biologically hard to degradate
    - 50 % - 80 % of NOM



- different **sources**
  - Allochthon (organic mulch of soils)
  - Autochthon (phytoplankton, detritus inside waterbody)

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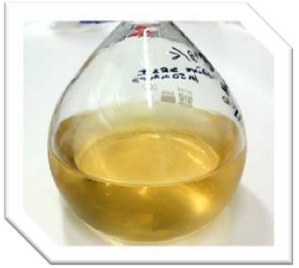
Characterization of humic substances



- Differentiation after molecular size

increasing molecular size

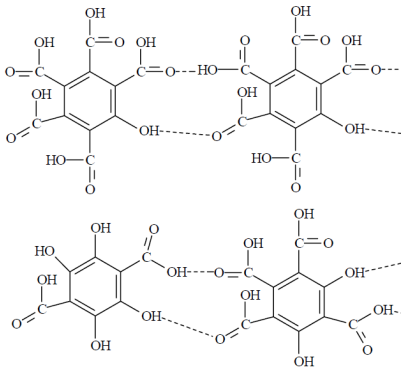
but **decrasing** solubility

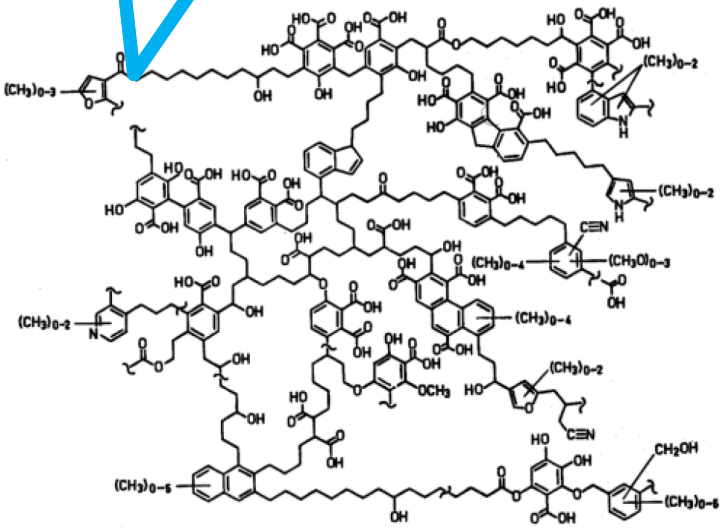
can be found in water

Fulvic acids

Humic acids

Humics





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Properties/relevance of NOM

- **relevance for drinking water**
  - aesthetics: color
  - odour and taste
  - reaction with oxidants and disinfection agents (O_3, Cl_2, ClO_2)
  - flocculation/filtration (retention period of filters)
  - adsorption (competition to trace compounds)
  - membrane filtration (fouling caused by biopolymers)

- **relevance for environment**
  - acid character, part of natural buffer system
  - responsible of nutrients in soils
  - adsorption of harmful substances and heavy metals

Knowledge about composition and alteration of NOM is important

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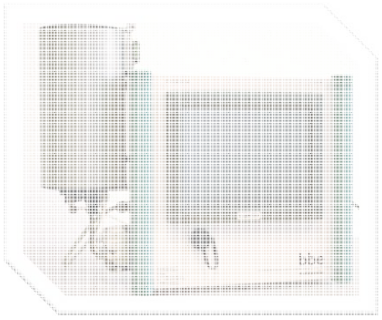
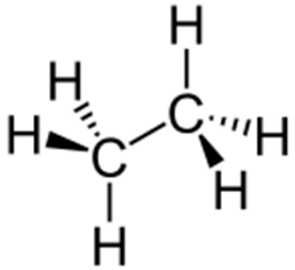
- TZW method
- Application Example

- Introduction of new device



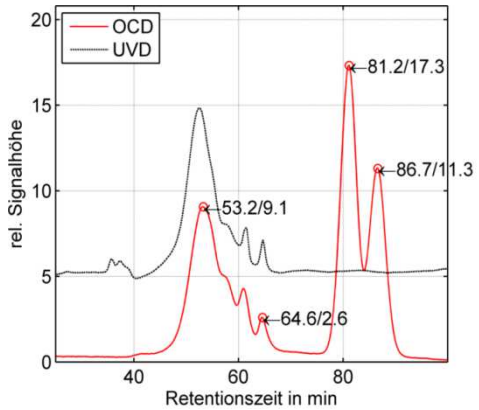
Analysis of NOM

- Bulk parameters
  - TOC/DOC
  - $SUVA_{254}$



DOC = ∑C-Atoms

- Chromatographic methods
  - SEC: size exclusion chromatography
  - Determination of humic substances and biopolymers



- Fluorescence (!)
  - Bridge between simplicity of SUVA and complexity of SEC
  - economically priced

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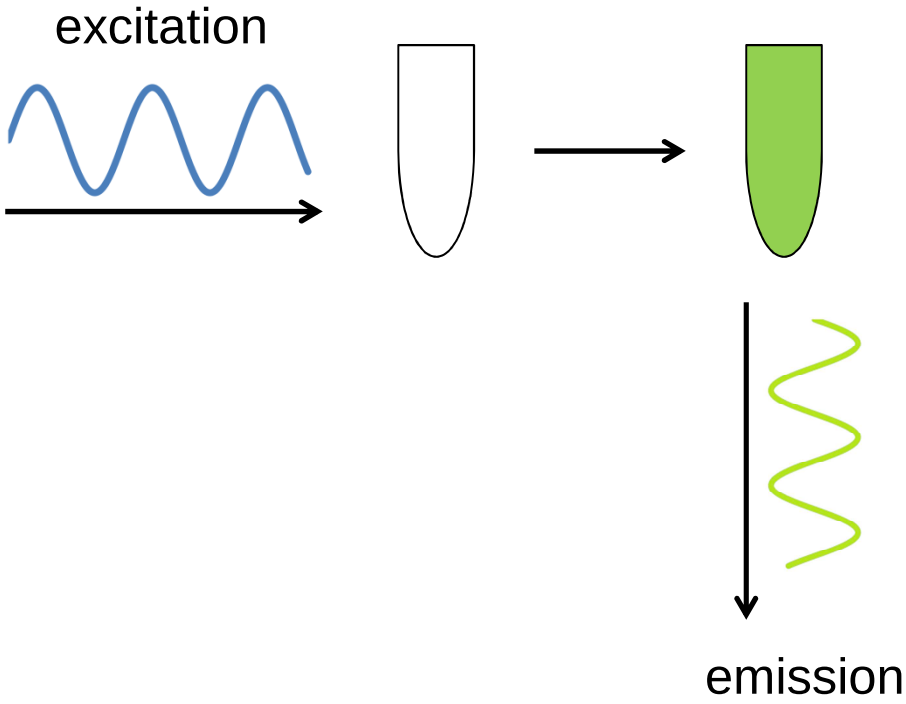
Fluorescence Spectroscopy

- Two dimensional technique (excitation & emission)

Source: Thermo Scientific



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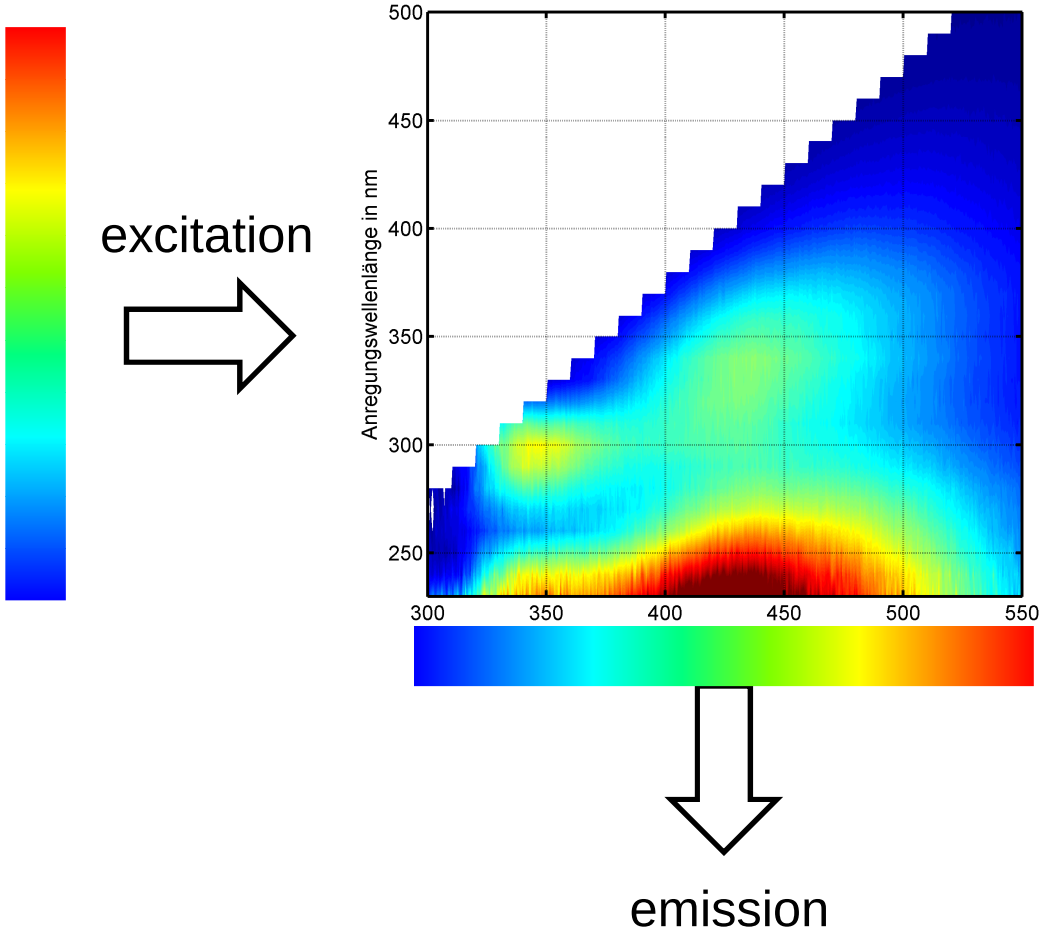
Fluorescence Spectroscopy

- Two dimensional technique (excitation & emission)

„map“ of a water sample



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TZW method

- TZW developed a method which allows the **characterization** and **quantification** of **single fluorescent patterns** of NOM
- Method can be **applied to a single „map“** and allows the determination of the following parameter

Humic substances

- Differentiation after molecular size
  - Concentration of lower molecular **fulvic-acid** like fraction in mg/L carbon
  - Concentration of higher molecular **humic-acid** like fraction in mg/L carbon
- Mean molar mass in g/mol

Biopolymers

- Protein concentration in mg/L carbon
- Tryptophan containing peptides in µg/L trytophan-equivalents

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Applications: Monitoring of water quality

Raw water

Treatment

- Flocculation
- Activated carbon
- Disinfection

Tap water

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Applications: Monitoring of water quality

Raw water

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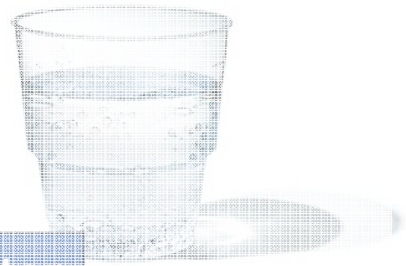
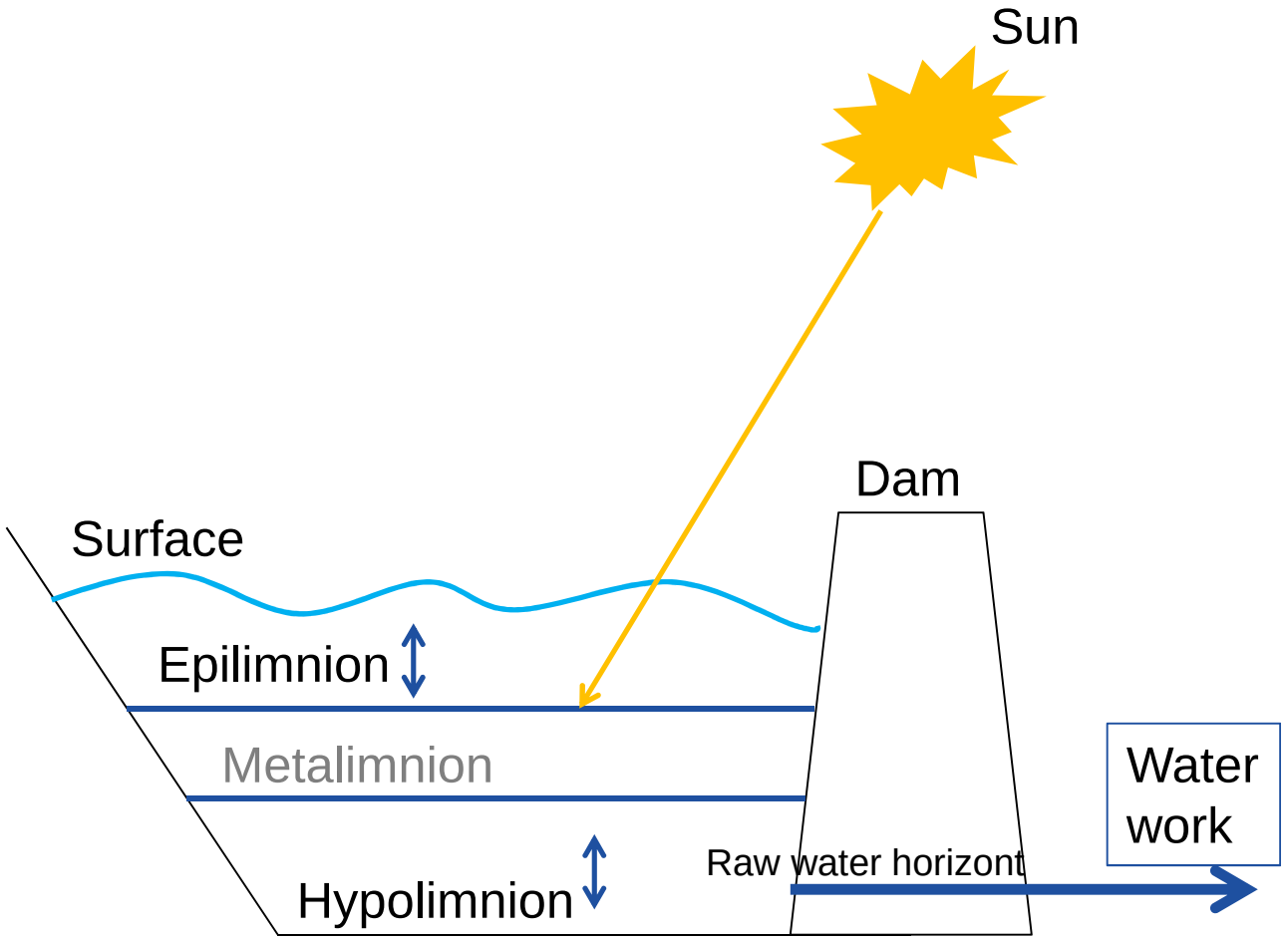
Disinfection



Tap water

- Sampling: different depths



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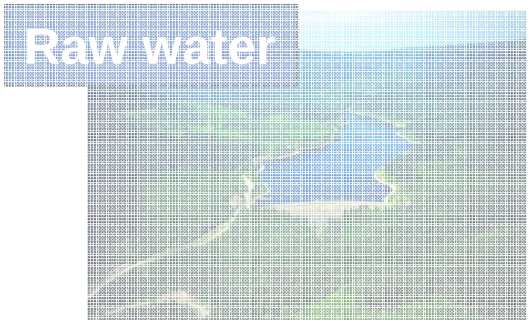
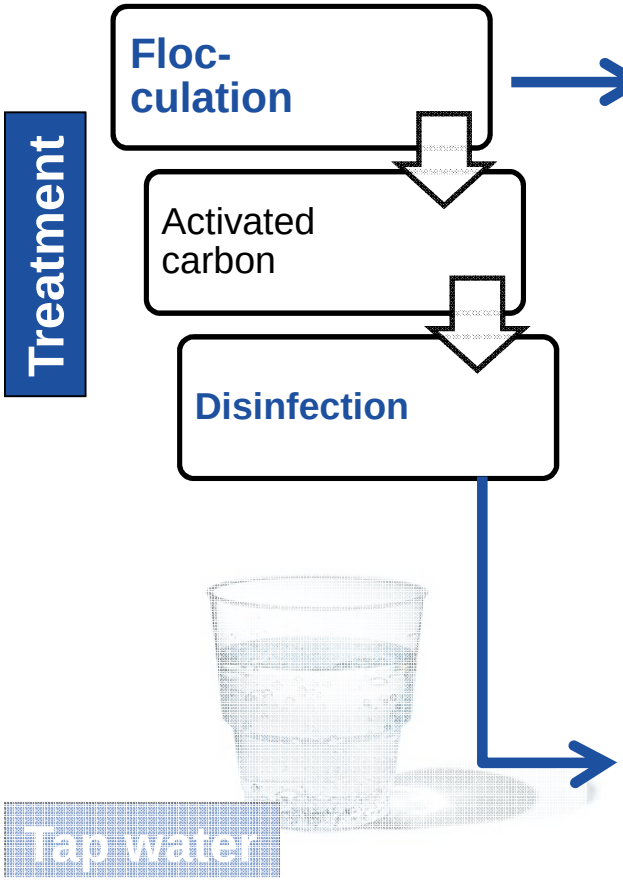
Applications: Monitoring of water quality





- Removal of humic substances and particles
  - Particles
    - reduction of disinfection efficieny
    - Source of deposits in distribution networks
  - Humic substances
    - Formation of disinfection byproducts
    - Increase of chlorine demand
- Disinfection with chlorine

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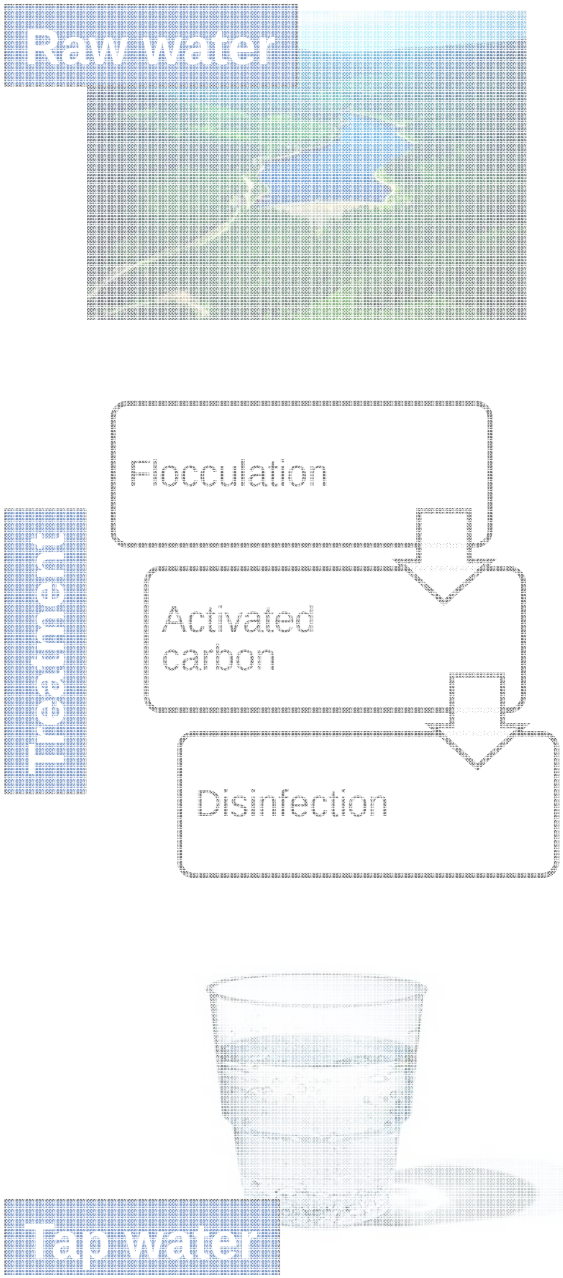
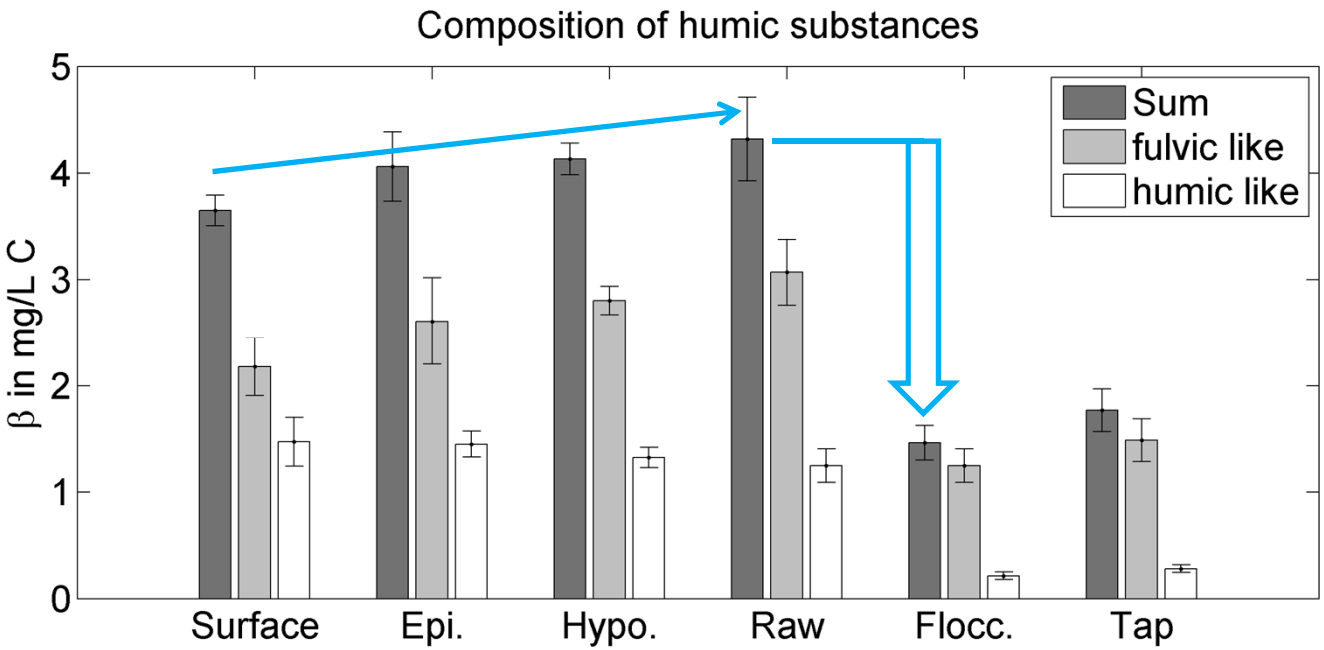
Applications: Results





- humic substances = main component
- Increase of concentration with depth
- High elimination during floccuation
  - Sum: 66 % removal
  - Fulvics: 59 %
  - Humics: 83 %

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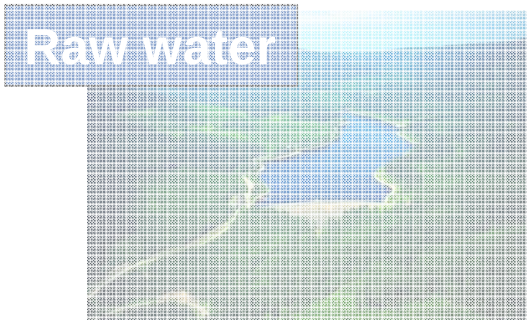
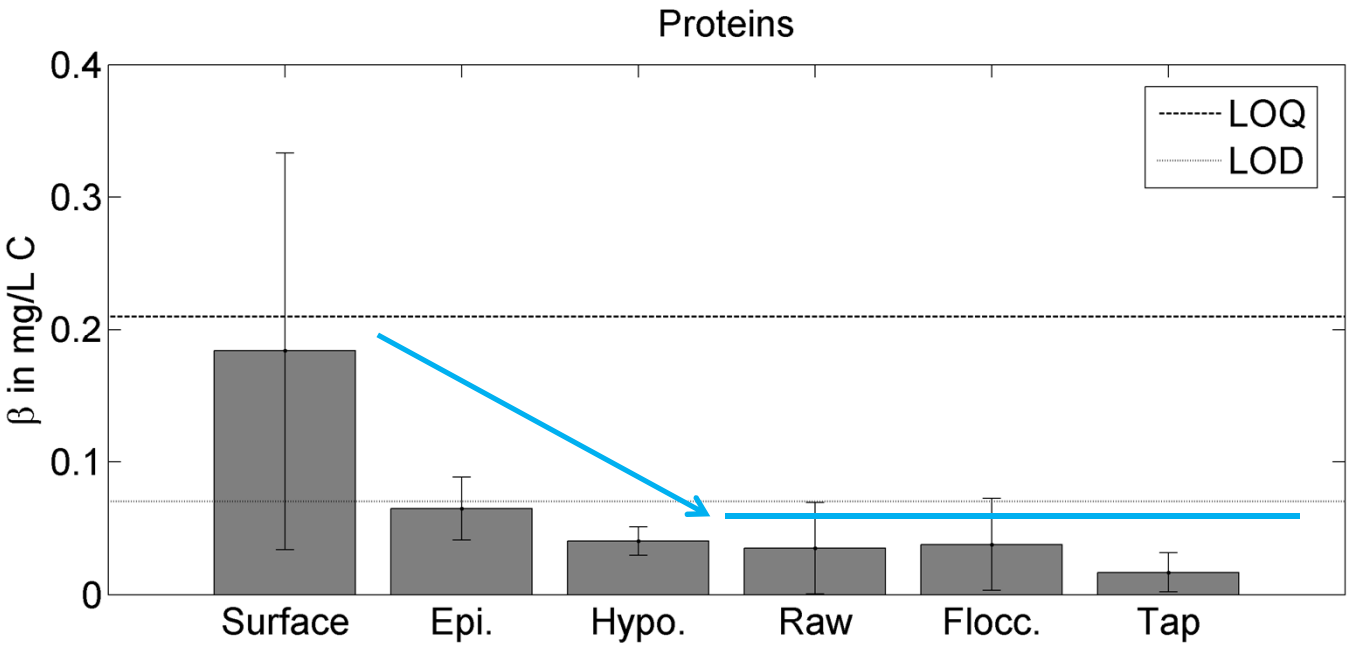
Applications: Results



Flocculation

Activated carbon

Disinfection



- Proteins = minor component
- Decrease of concentration with depth
  - Surface = Primary Production (PP)
- Low nutrient concentration and poor PP
- No changes during treatment

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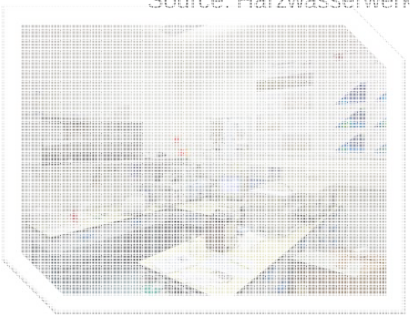


Introduction of new device

Development of online device

- Cooperation between TZW and bbe Moldaenke
- Enables **online measurement** of important drinking water parameters in one device (**multiparameter**)

Chlorophyll

- Chlorophyll concentration of green, bluegreen and diatoms

Humic substances

- Lower molecular fraction (fulvic acids like)
- Higher molecular fraction (humic acids like)
- Estimate of mean molar mass

Biopolymers

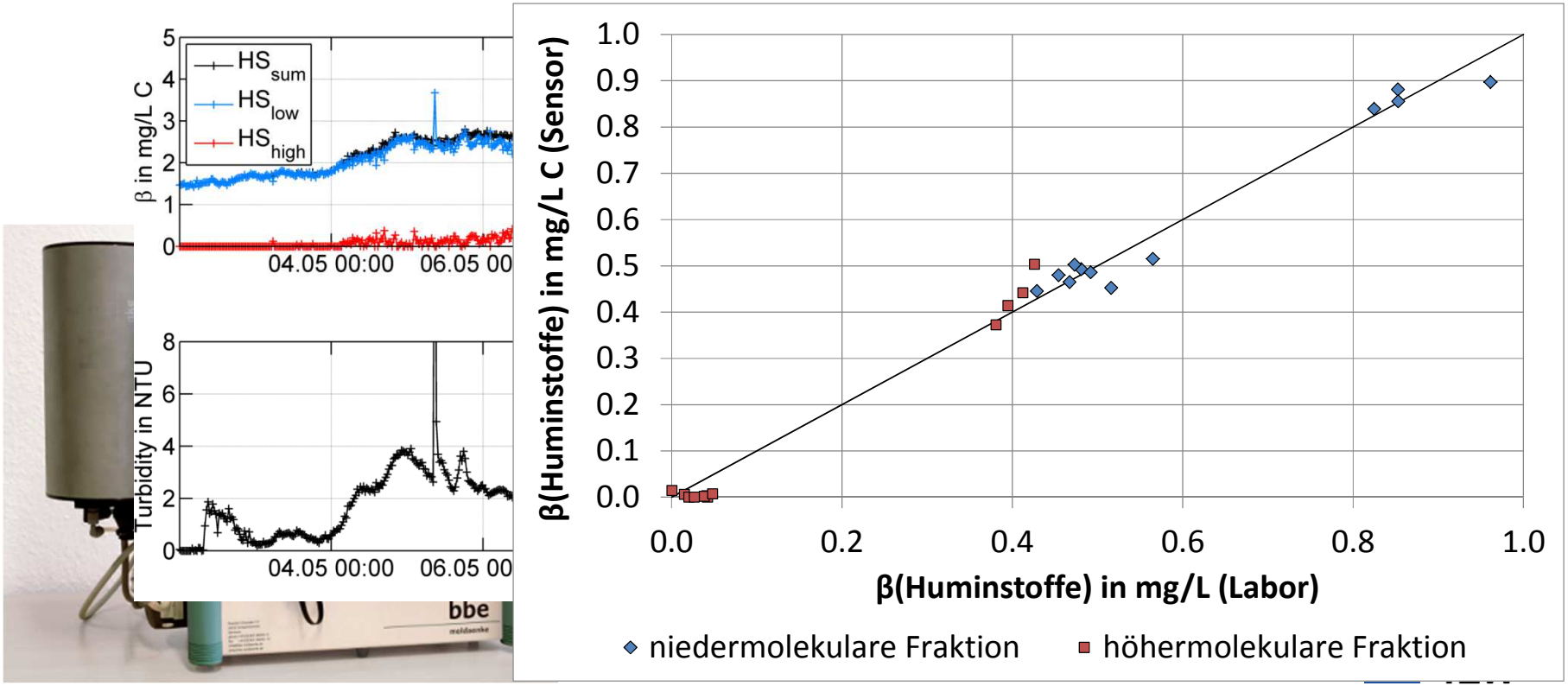
- Concentration of proteins

Further parameters

- $SUVA_{255}$
- Turbidity
- Temperature

Test stage: application of 2 prototypes

- Application of 2 prototypes at two different waterworks
  - Drinking water reservoir
  - River (direct taking)



Summary

- Natural organic matter includes (NOM)
  - Humic substances
  - Biopolymers
  - Chlorophyll
- NOM is an important parameter for drinking water treatment
- NOM can be analyzed by a fluorescence method, developed by TZW
- Cooperation of TZW and bbe Moldaenke leads to a new online device which allows the online measurement of NOM

The End

Thank you for attention!

Questions? Don‘t be shy to ask!

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