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TECHNISCHE UNIVERSITÄT DRESDEN

Performance of existing waterworks and conclusions for future drinking water treatment

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Integrated Water Resources Management in Distrito Federal – DF
June 4-6, 2013

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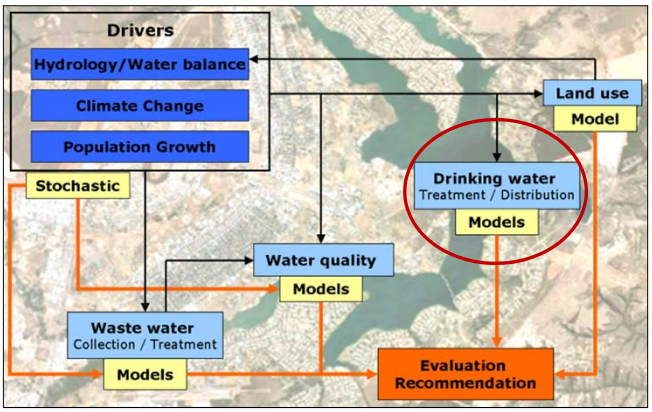
1 Sustainable water supply as part of IWRM



- Predict consequences of different management strategies depending on external factors
- Find optimal management strategies for future

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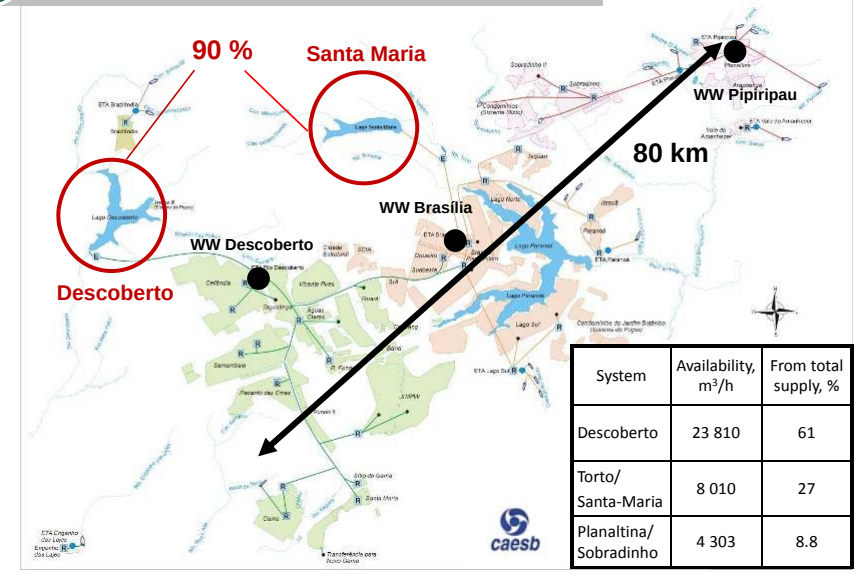
1 Sustainable water supply as part of IWRM

- **How do different factors influence surface water quality?**
- **How can the existing treatment be adapted?**
- **What are the solutions for future treatment?**

2 Water supply system of Brasília DF



System	Availability, m³/h	From total supply, %
Descoberto	23 810	61
Torto/ Santa-Maria	8 010	27
Planaltina/ Sobradinho	4 303	8.8

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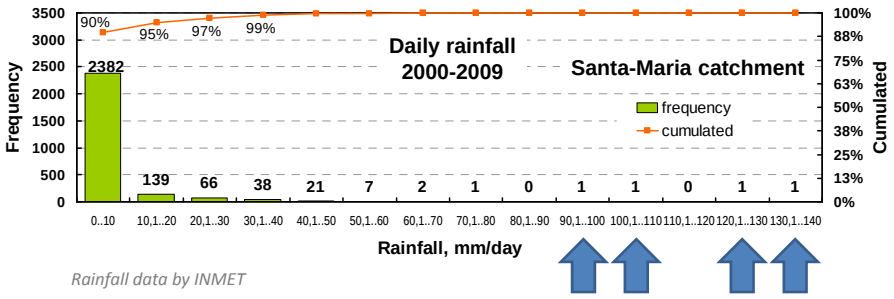
3 Specific weather conditions

- Average annual precipitation ca. 1 550 mm/year (WMO 2011)
- Dry and rainy seasons
- Few intensive rainfalls with up to 140 mm/day
- May cause significant changes in raw water quality
- Uneven rainfall distribution across the district



Rainfall data by INMET

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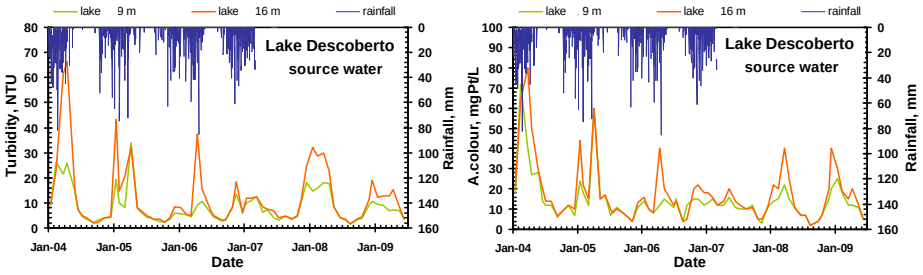
3 Source water quality

- High quality surface water
- Increases of turbidity and apparent colour caused by rainfall-induced erosion
- Fluctuations are more pronounced in rivers and less in lakes (buffering)
- Raw water quality to be treated within one facility varies by one order of magnitude



Rainfall data by INMET
WQ monitoring data by CAESB

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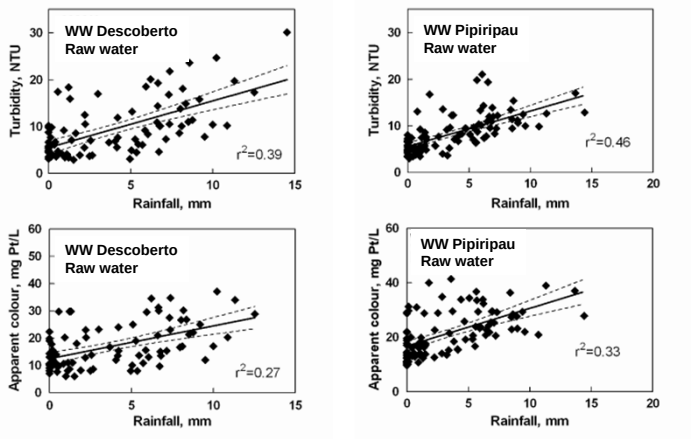
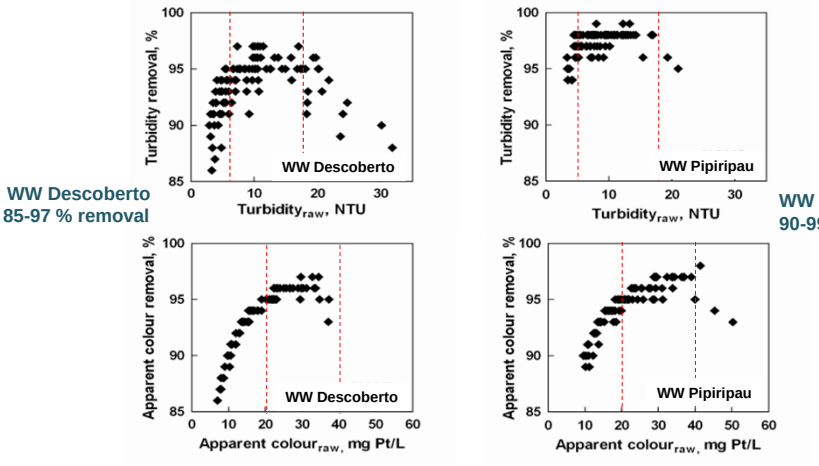
3 Source water quality



- Fluctuations of particulate matter – primary challenge to waterworks
- Rapid adjustment of the treatment process necessary

WQ monitoring data by CAESB

4 Evaluation of existing treatment



WW Descoberto
85-97 % removal

WW Pipiripau
90-99 % removal

- Always compliance with DW legislation
- Most stable process at turbidity 5-18 NTU and app. colour 20-40 mgPt/L in raw water
- WW Brasília: inconsistent → different mechanisms of turb. and a. colour removal

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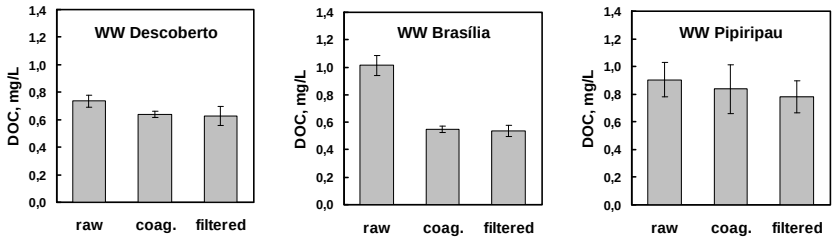
4 Evaluation of existing treatment

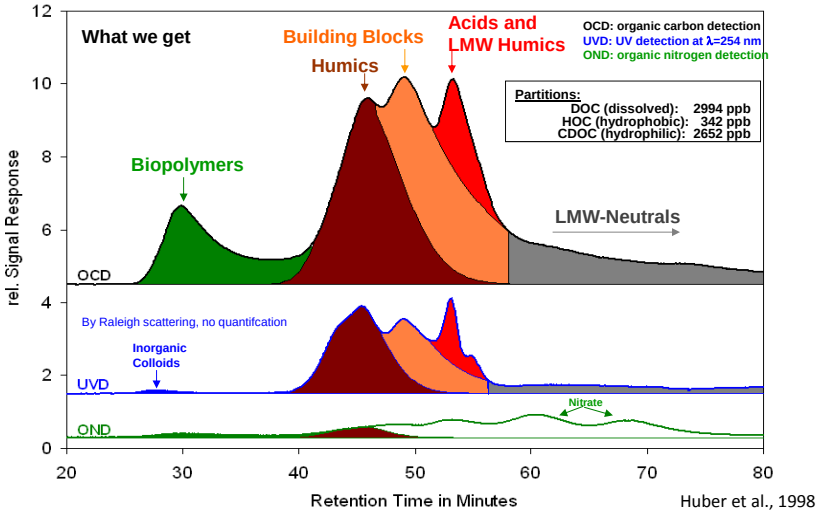
Natural Organic Matter (NOM)



- Low bulk DOC
- No significant seasonal pattern (slightly higher in rainy season)
- WW Pipiripau: highest variations of DOC in raw water → rain-induced washout from upper soil horizons (agriculture)

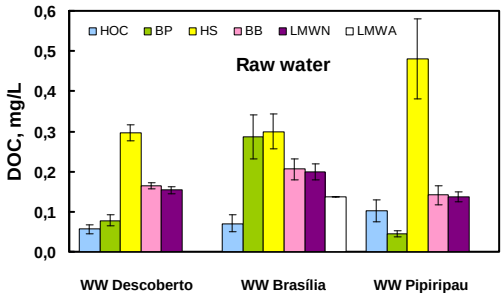
4 Evaluation of existing treatment

NOM characterisation: Liquid-Chromatography - Organic Carbon Detection



4 Evaluation of existing treatment

Natural Organic Matter (NOM)

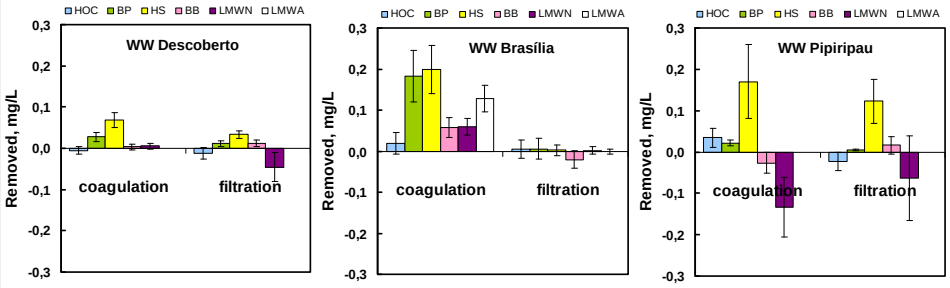


HOC	hydrophobic OC
BP	biopolymers
HS	humic substances
BB	building blocks
LMWN	low molecular weight
LMWA	neutrals and acids

- Humic substances contribute to 30-50 % of DOC in raw water
- River water (WW Pipiripau): highest HS content
- Lake Santa-Maria (WW Brasília): 1/3 of DOC composed by biopolymers (algae)

4 Evaluation of existing treatment

Natural Organic Matter (NOM)



- DOC removed mainly by coagulation
- High and medium MW fractions removed preferentially
- No removal of LMW fractions

HOC	hydrophobic OC
BP	biopolymers
HS	humic substances
BB	building blocks
LMWN	low molecular weight
LMWA	neutrals and acids

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4 Evaluation of existing treatment

Main conclusions:

- High variations of particulate matter between the seasons and during rainy season
- In most sources its increase is due to rain-induced erosion
- Raw water qualities of sources to be treated within one facility differ + difference between seasons → challenge of rapid adjustment
- Finished water quality is significantly affected by the raw water quality

5 Suggestions for future treatment and distribution

- Support of treatment via (online) analytical and monitoring methods
  - Turbidity
  - TOC/DOC, UVA_{254}
- Optimisation of coagulation/flocculation procedure
  - Prediction of coagulant dose
  - Floc properties (e. g. PDA, SCD)
  - Modelling
- Introduction of more sophisticated control strategies
  - Model based
  - artificial neural networks
- Introduction of membrane filtration to conventional treatment train
  → will guarantee constant drinking water quality

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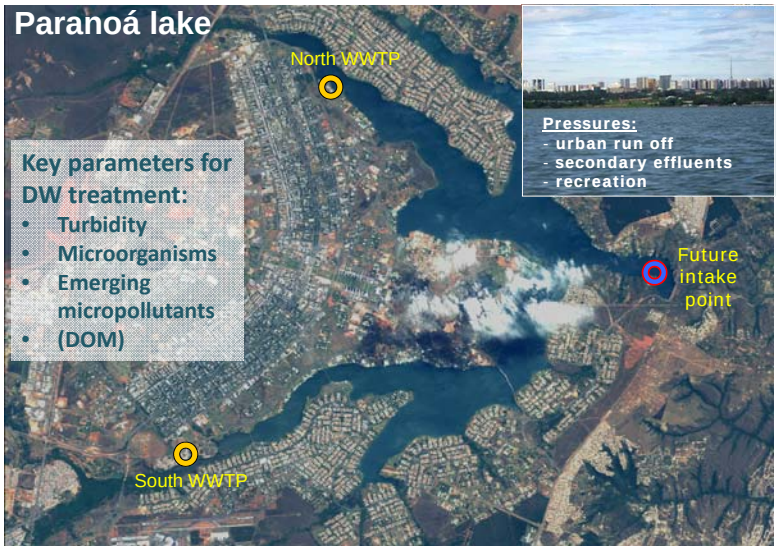
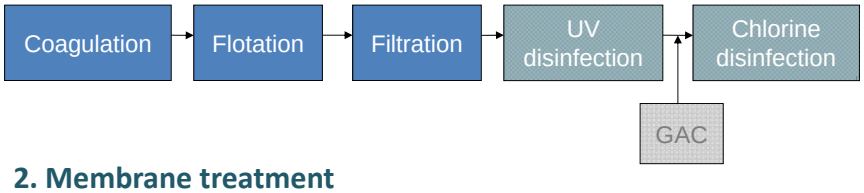
5 Suggestions for future treatment and distribution



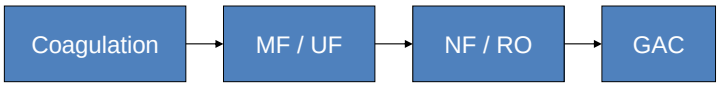
5 Suggestions for future treatment and distribution

Suggested concepts for treatment of Paranoá lake water

1. Conventional treatment



2. Membrane treatment



MF, UF, NF	Micro-, Ultra-, Nano-filtration
RO	Reverse Osmosis
GAC	Granular Activated Carbon

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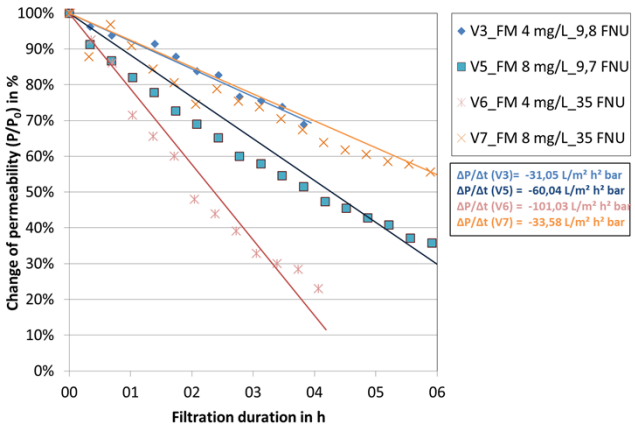
5 Suggestions for future treatment and distribution

Ultrafiltration of low- and high-turbid river water

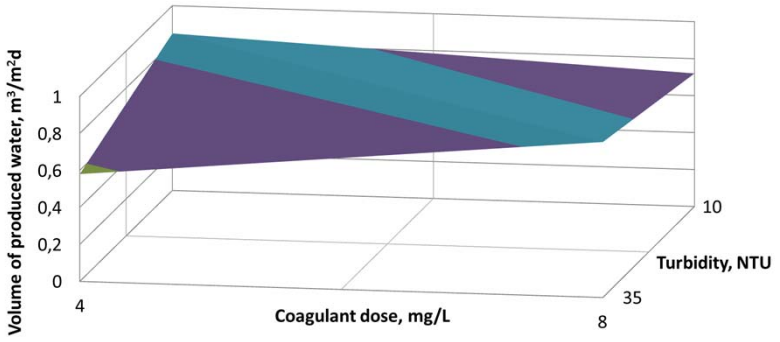
Influence of turbidity and coagulation dose on membrane permeability



5 Suggestions for future treatment and distribution

Ultrafiltration of low- and high-turbid river water

Influence of turbidity and coagulation dose on volume of produced water



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5 Suggestions for future treatment and distribution

Model for NOM removal by coagulation

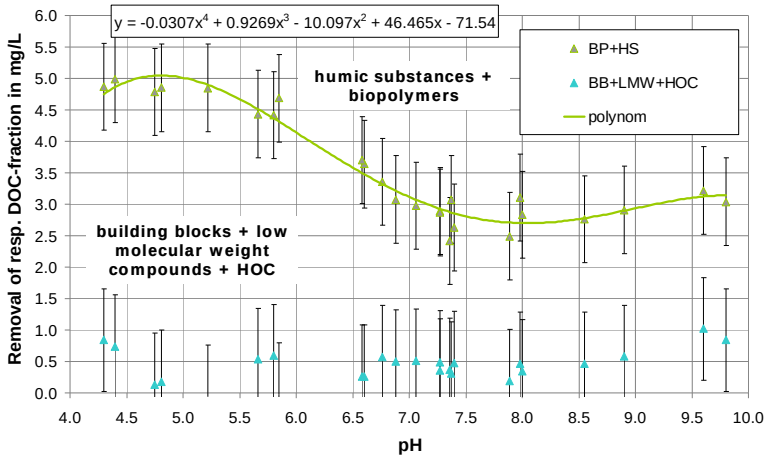
Approach:

- Description of DOC removal by applying a semi-empirical model based on Langmuir adsorption isotherm
- Calculation of residual DOC concentration after coagulation depending on:
  - DOC of the raw water
  - coagulation conditions: coagulant dosage and pH

5 Suggestions for future treatment and distribution

Model for NOM removal by coagulation

pH-dependency of humics adsorption:



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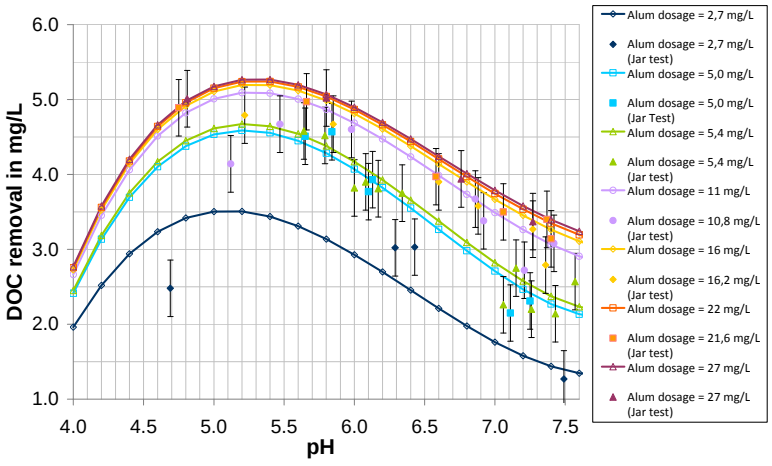
5 Suggestions for future treatment and distribution

Model for NOM removal by coagulation

DOC removal:

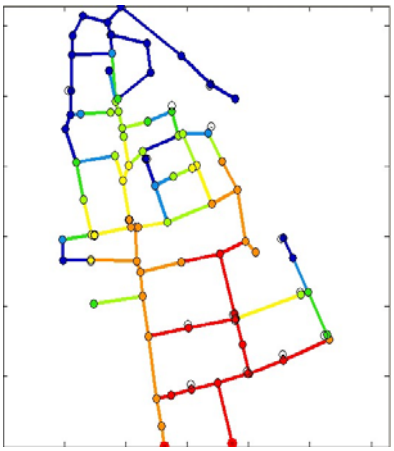


5 Suggestions for future treatment and distribution

Water quality modeling in the distribution system

In order to optimize the operation strategies:

- Optimize the disinfectant doses at waterworks
- Determine the position of booster chlorination stations



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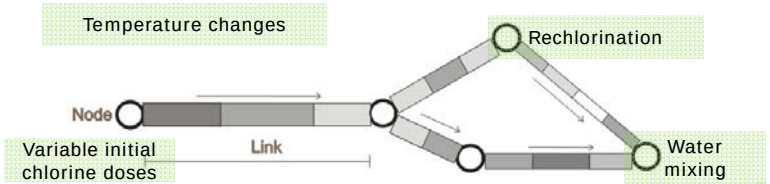
5 Suggestions for future treatment and distribution

A second order model with a variable reaction rate coefficient (VRRC) for chlorine decay was developed

- Changing reactivity of reactants
- Prediction of chlorine residual with invariant parameters under all the chlorination conditions



$$Cl + X \xrightarrow{k_{ov}} P \longrightarrow \frac{dCl(t)}{dt} = Cl(t) \times k_{ov} \times (Cl\_demand - Cl(t))$$

5 Summary

Contributions to IWRM

- Raw water characteristics analyzed and consequences for treatment derived
- Performance of present treatment analyzed and suggestions for future treatment made
- Chitosan as alternative coagulant studied and suggested, including impact on THM-formation
- Suggestions to raise public awareness as a part of IWRM made
- Model to describe optimal conditions for coagulation as function of raw water quality developed
- Model to describe chlorine consumption and THM formation in distribution systems as function of treated water quality developed
- Model for optimal UF-operation as function of raw water quality supplied

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