Iron removal at groundwater pumping station Harderbroek

Karin Teunissen
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kiwa
Partner for progress

TU Delft

Vitens

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Committee

Prof. ir. J.C. van Dijk
Dr. ir. L.C. Rietveld
Dr. ir. A.J. Abrahamse
H. Leijssen
Prof. dr. ir. M.C.M. van Loosdrecht

kiwa
Partner for progress

TU Delft

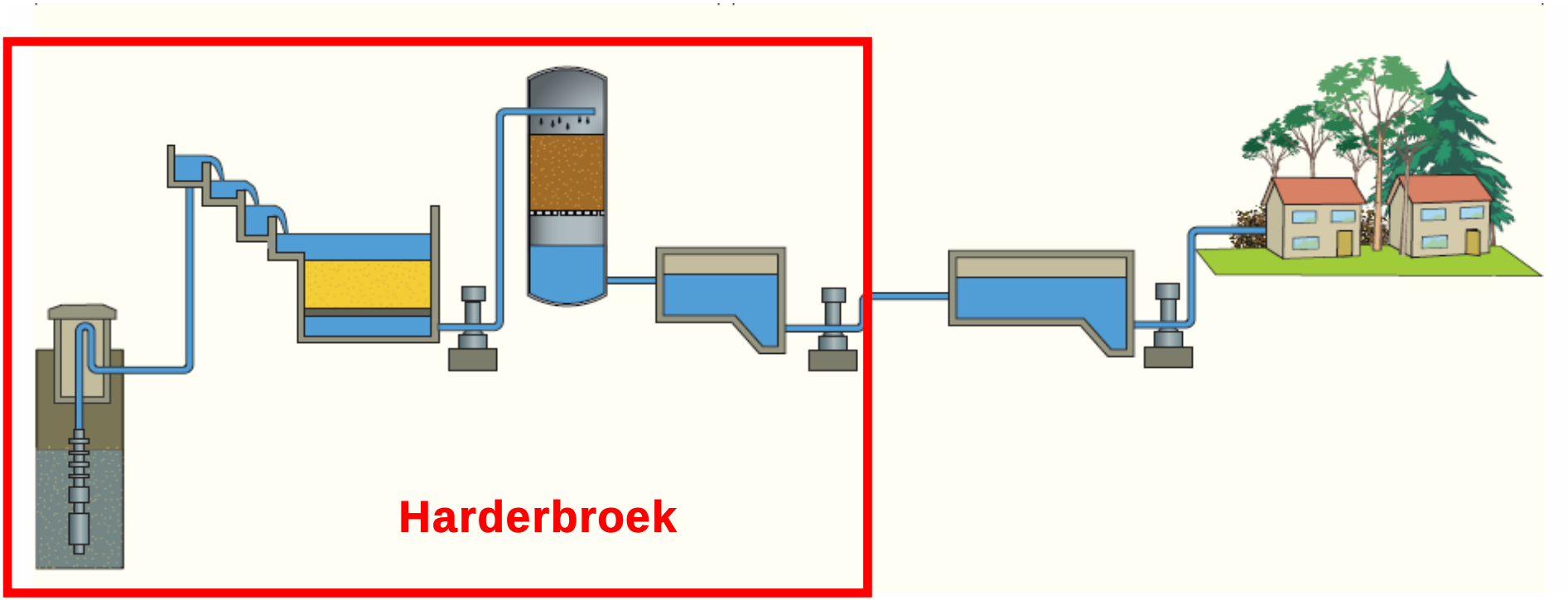
Vitens

Content

HARDERBROEK

Drinking water supply Flevoland

Treatment scheme Harderbroek

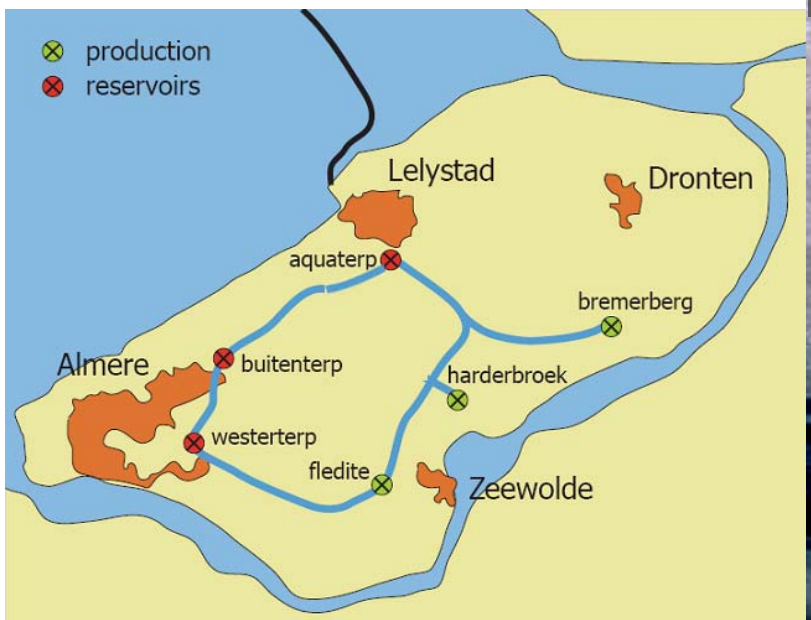


IRON REMOVAL

Iron removal

Iron is removed to avoid iron deposits

- In distribution system
- In laundry
- In drinking water



Iron in groundwater

Fe^{2+}

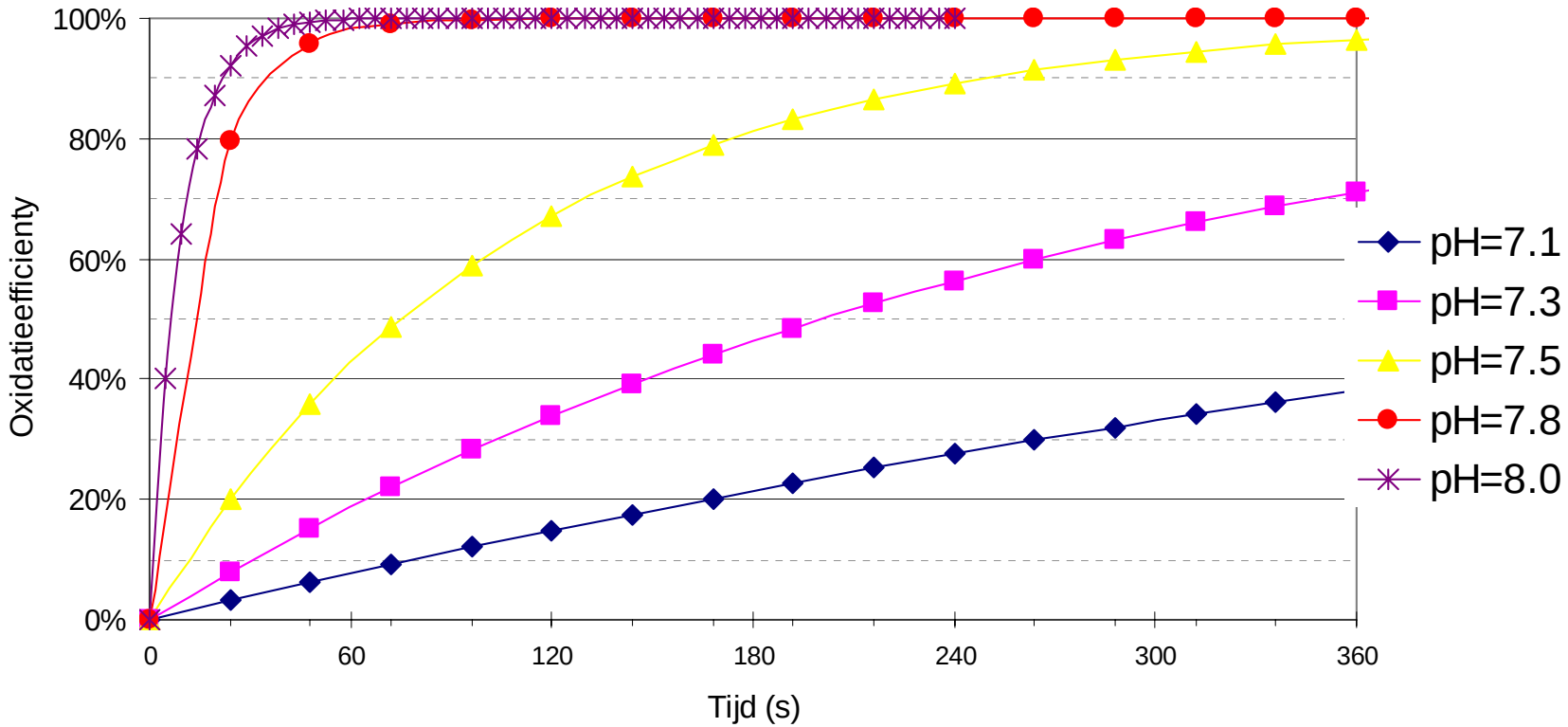
- **Present in anaerobic groundwater**
- **Dissolved in water**

Fe^{3+}

- **Forms iron flocks in water**
- **Gives brownish colour to the water**

Iron Removal

Iron oxidation: Fe^{2+} + oxygen → Fe^{3+}

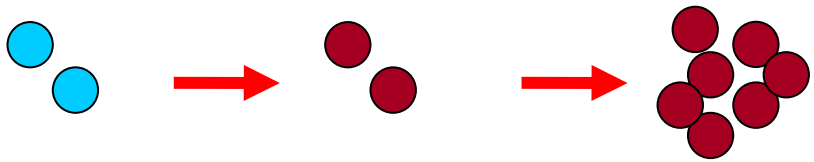


Iron removal

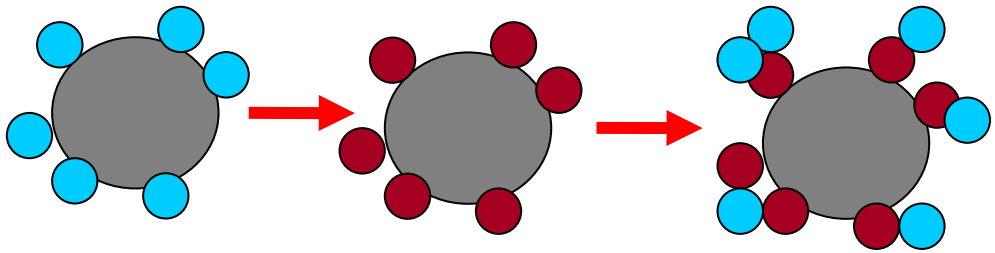
Fe^{2+} Fe^{3+}

Iron removal mechanisms:

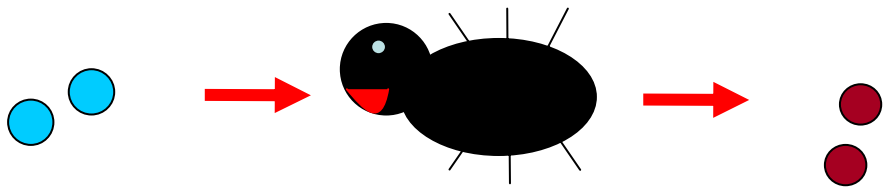
Flock filtration iron removal



Adsorptive iron removal

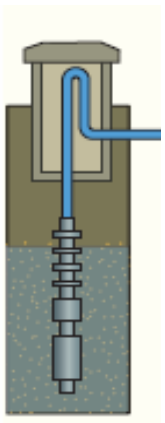


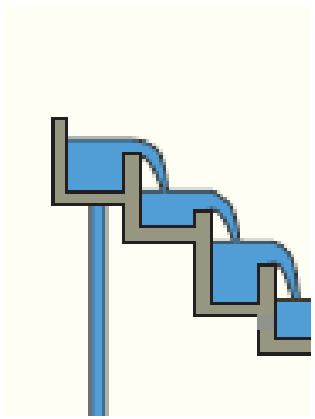
Biological iron removal

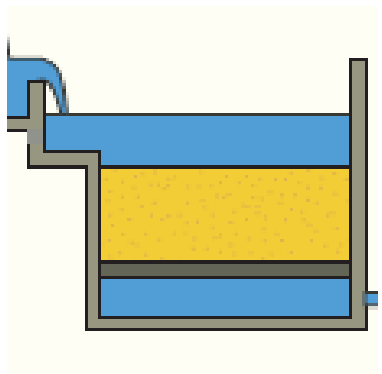


Iron Removal

Fe^{2+} O_2 Fe^{3+}



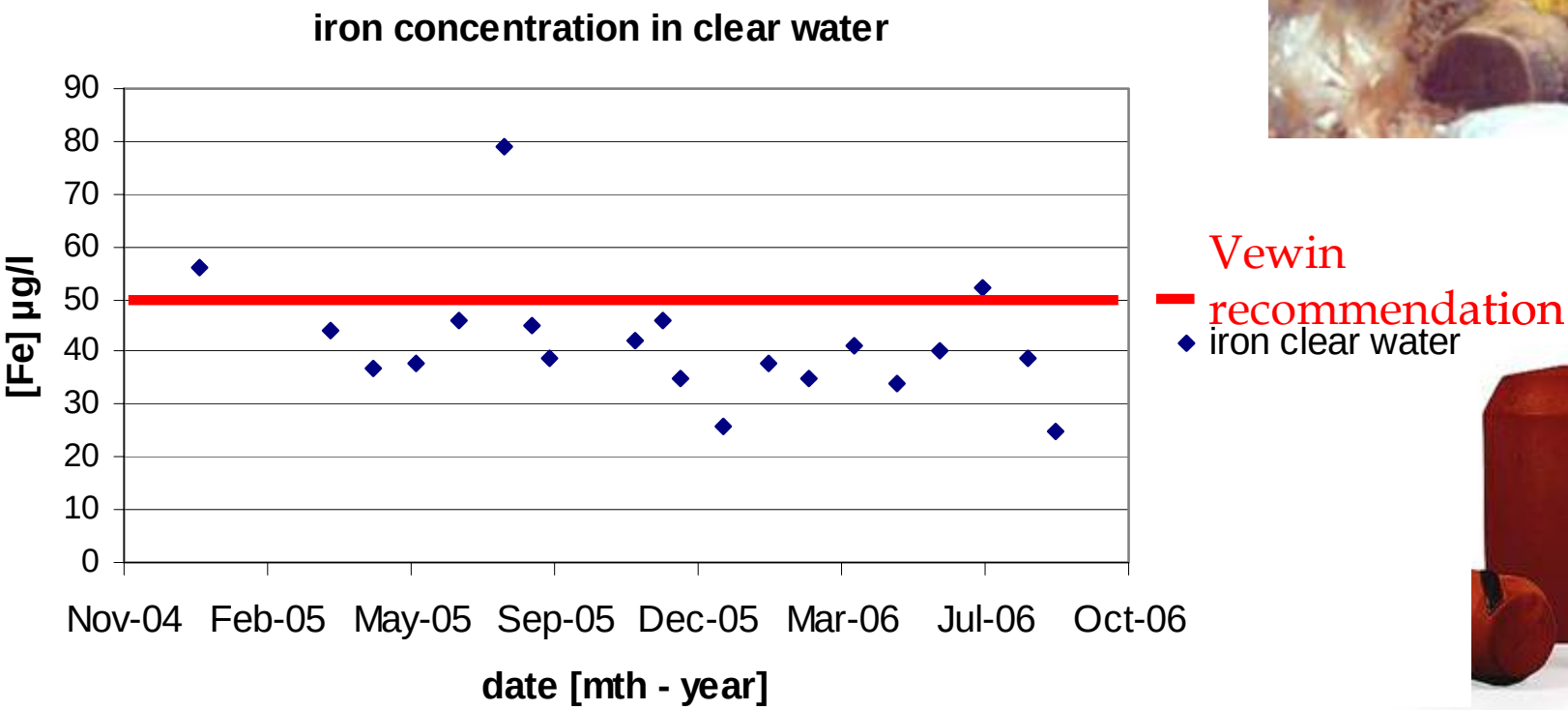




OBJECTIVE

Situation at Harderbroek

Expensive cleaning events



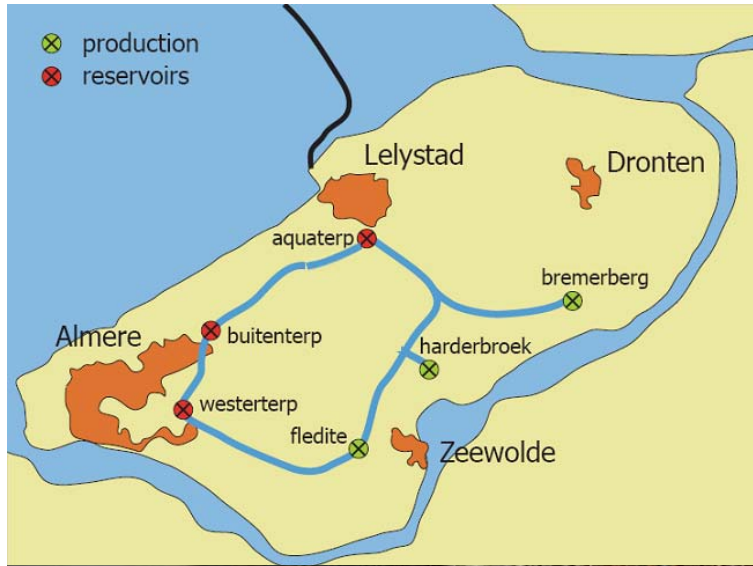
Harderbroek vs Fledite

Comparable water source

Same filters

Different aeration

- **Harderbroek cascade aeration**
- **Fledite spray aeration**



Hypothesis (1)

Formed iron hydroxide flocks breakdown in cascade or filter inlet construction

Small flocks break through the filters

Methods

Particle fingerprint

- To identify the presence of particles through the treatment plant in relation to operational events

Column experiments

- To get information on oxidation and flock formation

Model

- Generate insight in processes in the filter
- Elaborate future scenarios

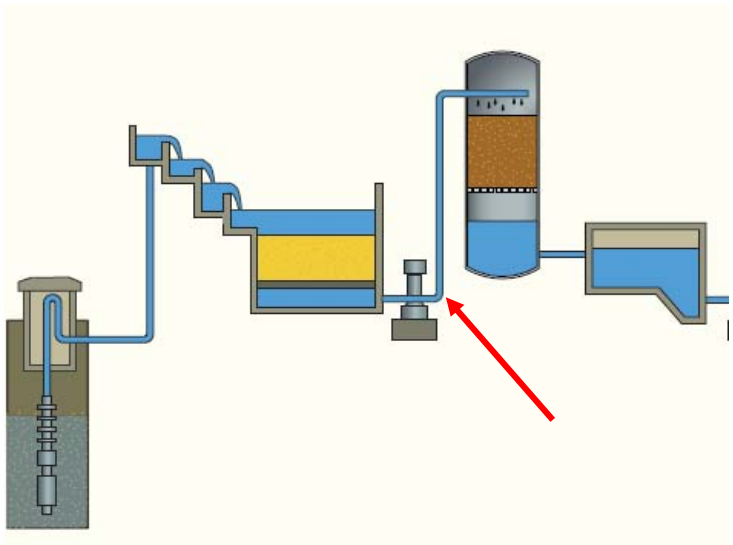
FINGERPRINT

Fingerprint

Particles identified with particle counters

Mainly focussed on filtration step

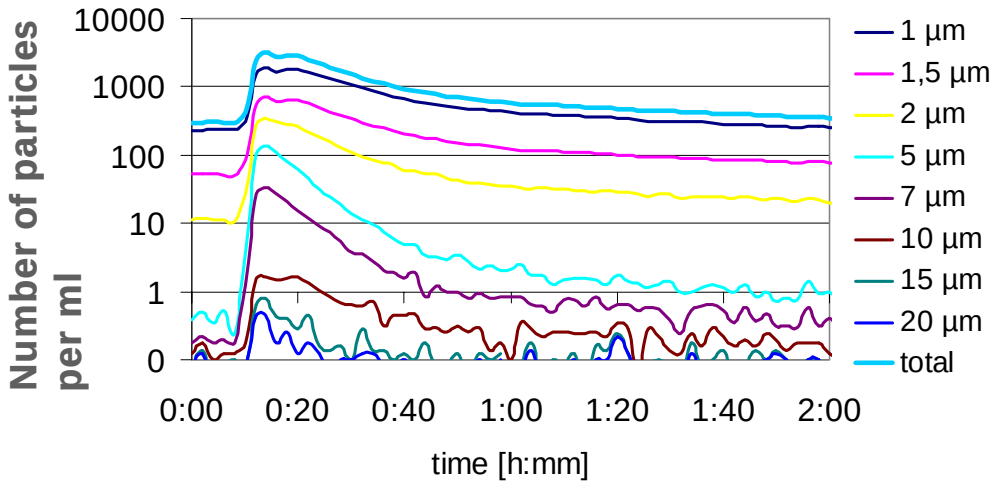
- After switching a filter
- After a backwash



Fingerprint results

After filter switch

Number of particles in filter effluent

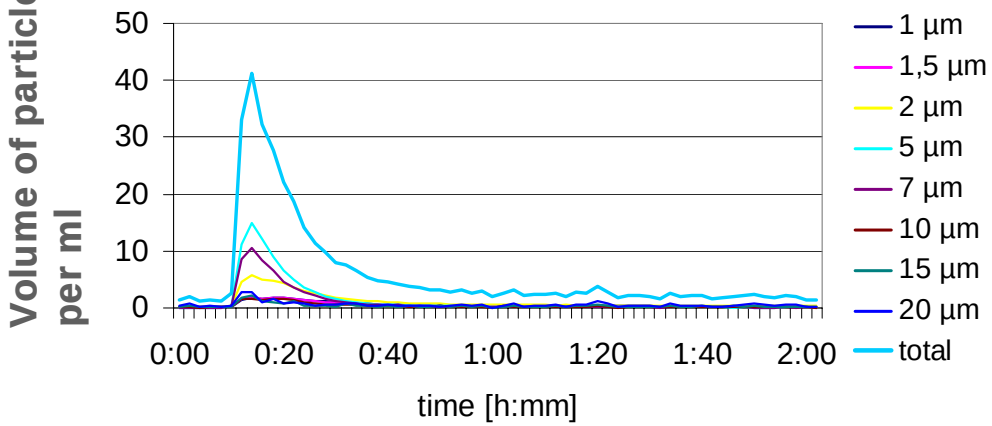


ppb

$$V = \frac{1}{6}\pi\sqrt{d_i \cdot d_j}^{3} \cdot number$$

1 part per billion =
1 volume of particles in
1,000,000,000 volumes of water

Volume of particles in filter effluent

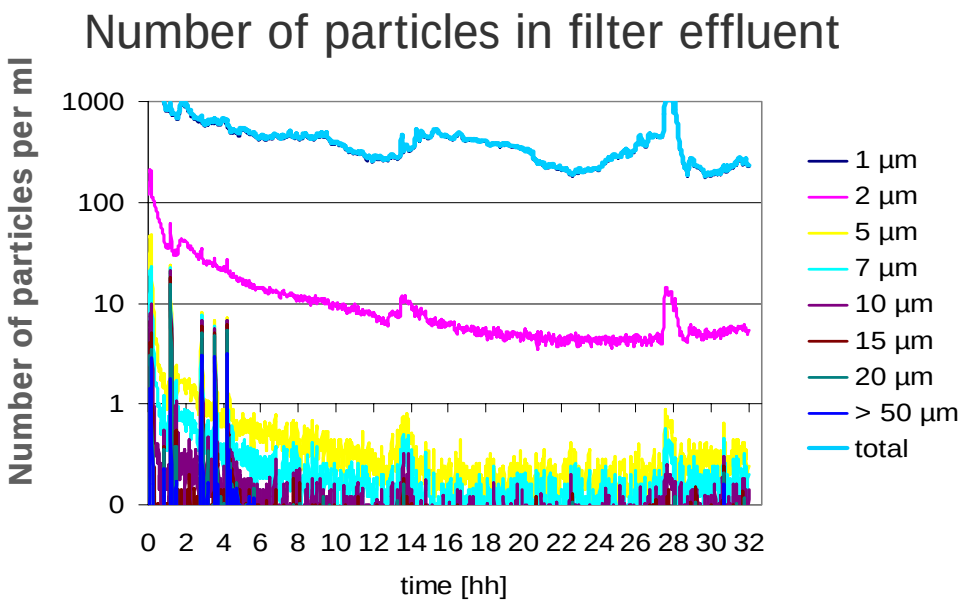


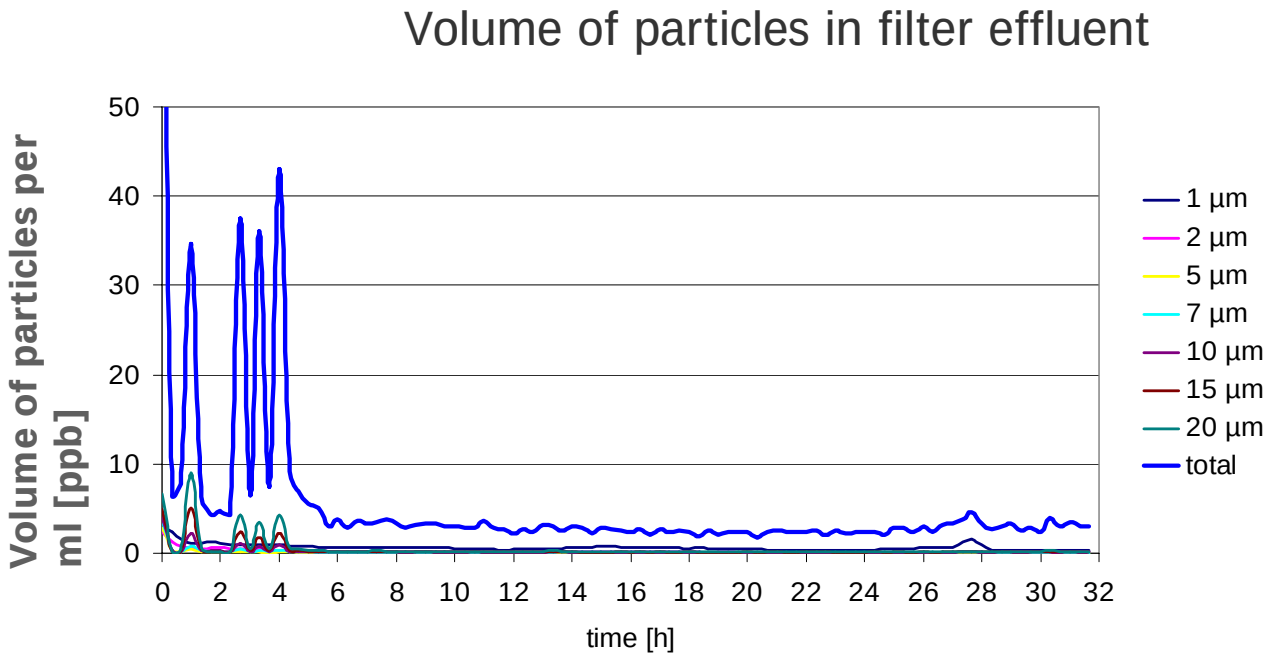
Fingerprint results

After backwash

Volume concentration increased for 4 hours

→ recirculation





Fingerprint

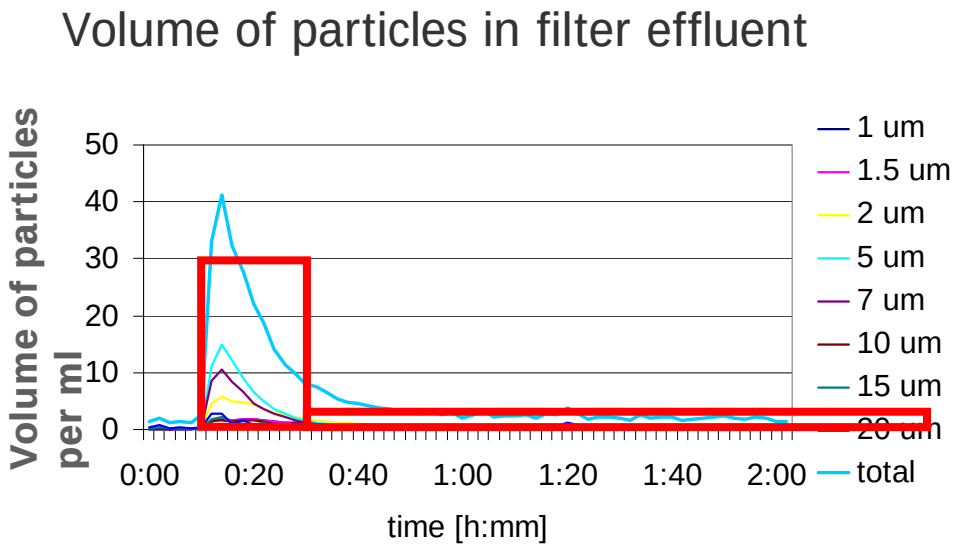
Volume load by events compared to stable operation

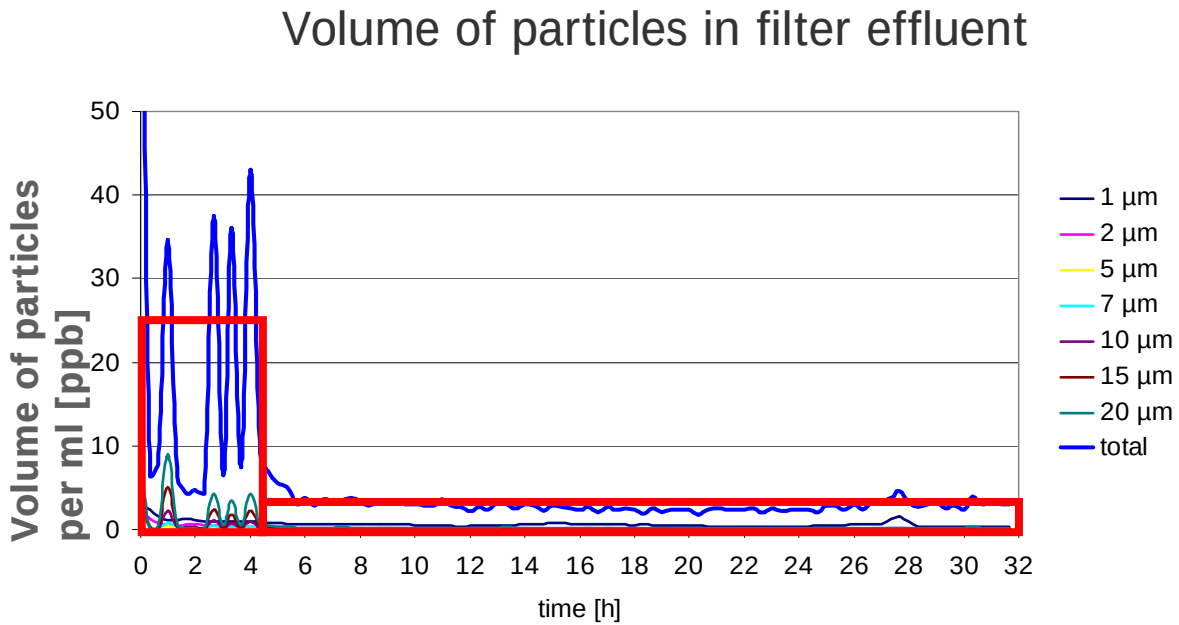
Switch filter

In 2 % of the time
15 % of the load

Backwash filter

In 13% of the filter run time 45 % of the volume load





Fingerprint

Aim

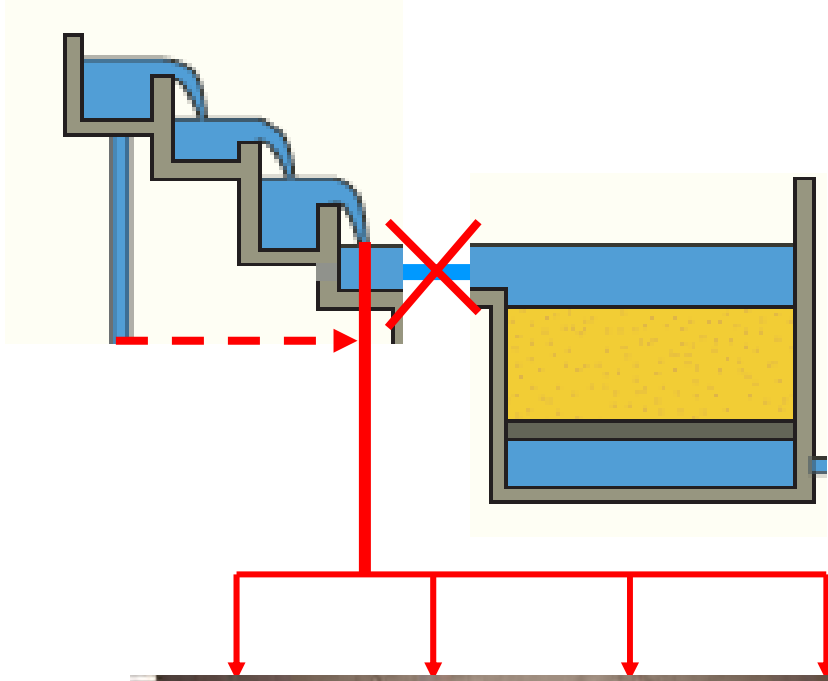
Average 1 ppb

Reduce peaks

Pumping station	Average ppb clear water	Cleaning frequency
Harderbroek	5	1 in 3 years
Franeker	15	1 in 1 year
Franeker + UF	1	1 in 10 - 12 years (expected)

COLUMN EXPERIMENTS

Column experiments



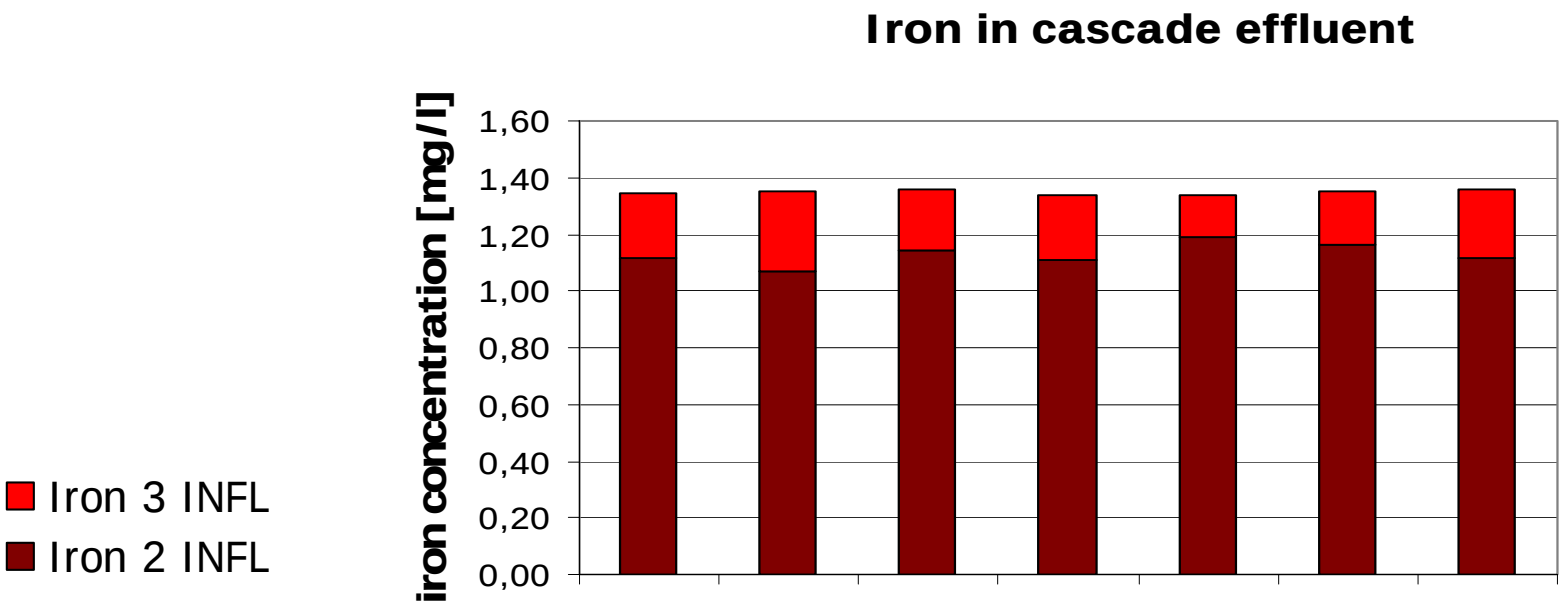
Part 1

- mixing intensity
- residence time
- and aeration

Part 2

- pH

Column results



Hypothesis (2)

pH in cascade effluent water too low for efficient oxidation

Column experiments

Experiments with pH increase

NaOH dosage

pH from 7.5 to 8.0

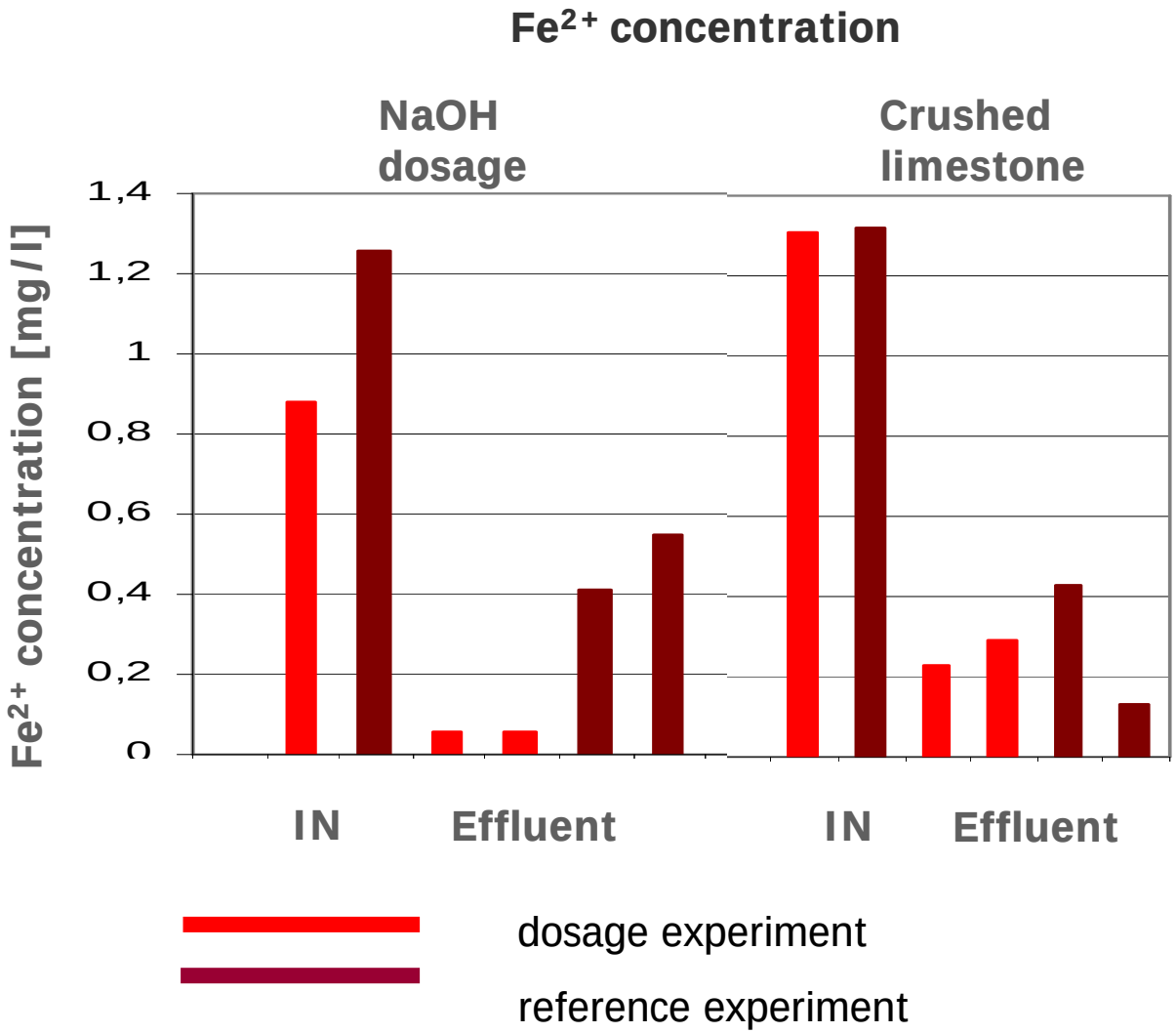
Crushed limestone filtration

pH from 7.5 to 7.7

Column results

Results

decrease Fe^{2+} concentration



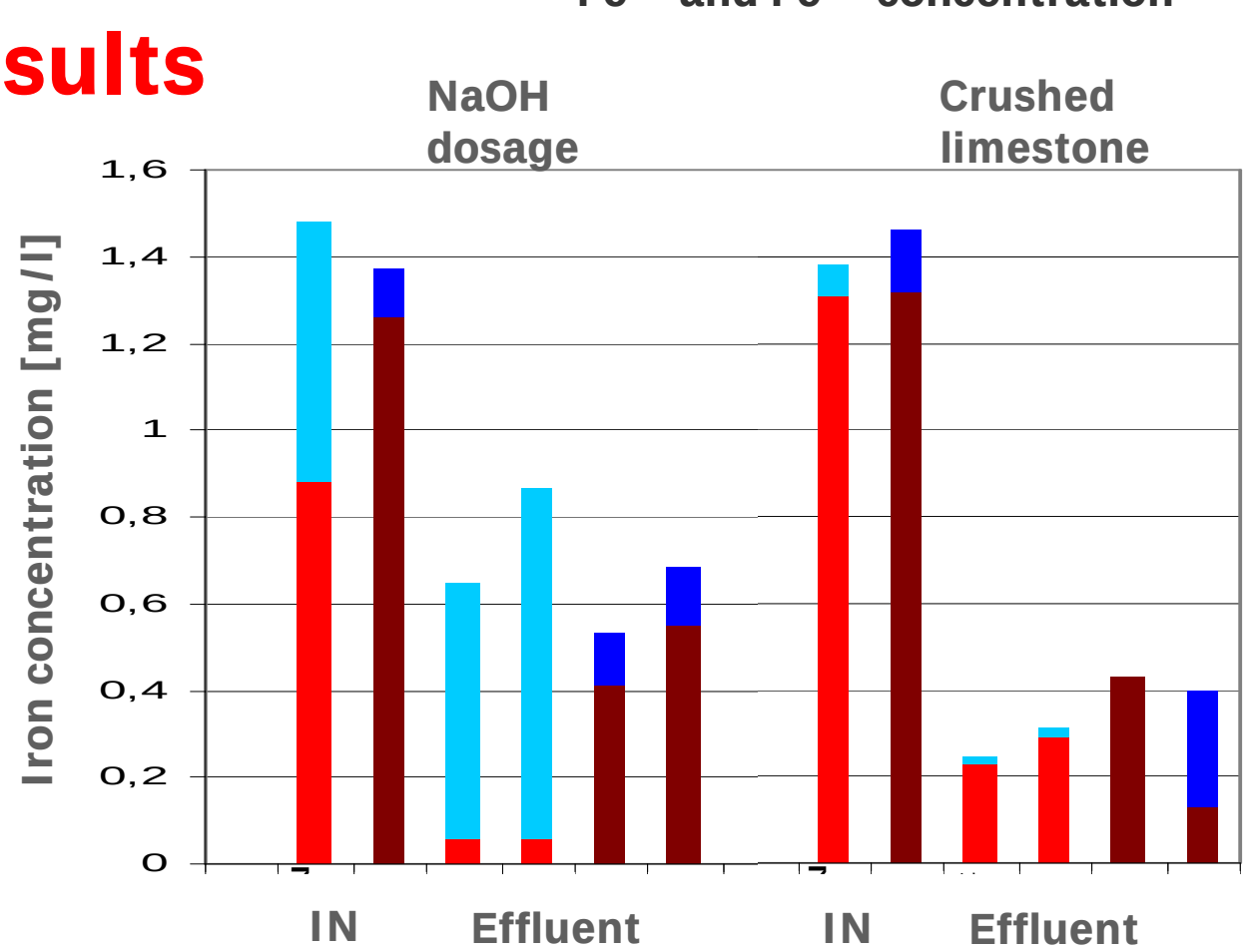
Column results

Results

Decrease Fe^{2+} concentration

Increase Fe^{3+} concentration

Total iron removal comparable



Fe^{2+} dosage experiment

Fe^{2+} reference experiment

Fe^{3+} dosage experiment

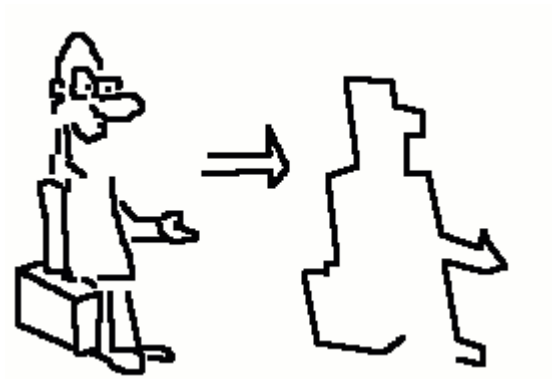
Fe^{3+} reference experiment

MODEL

Model

Modelling

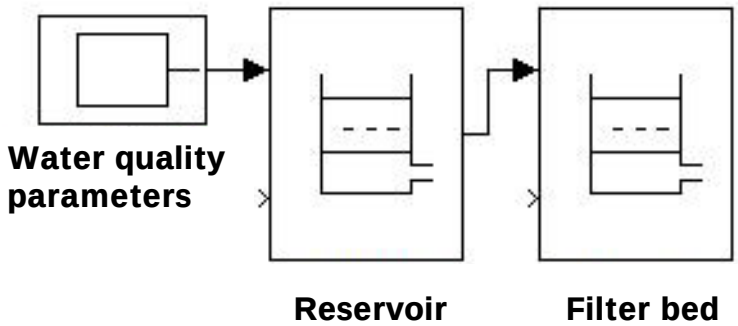
- Reflection of reality
- Simplification of reality
- Easy and fast method to vary parameters



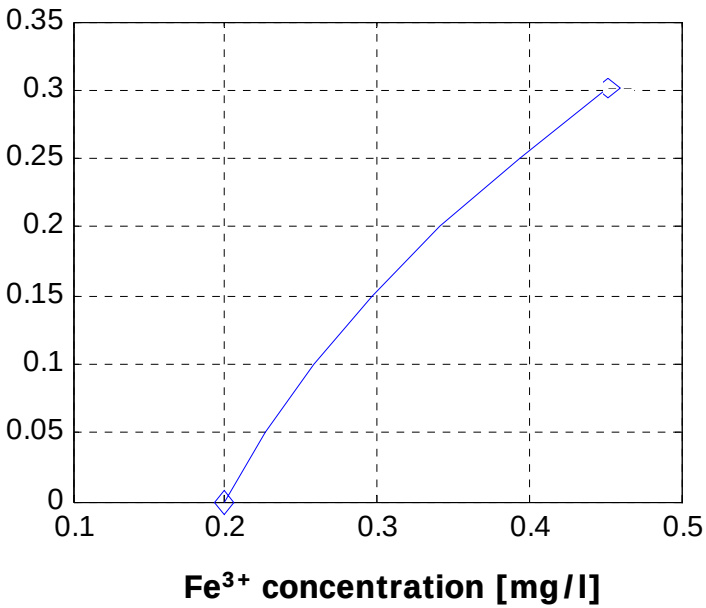
Model

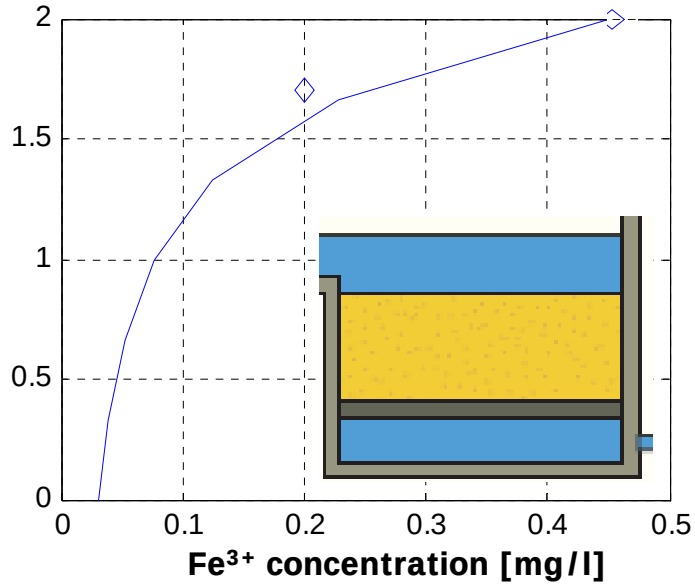
Iron removal model is created in Stimela

- First reservoir represents water phase before filter
  - Flock formation
  - No flock removal
  - No adsorption
- Filter represents filter bed
  - Flock formation
  - Flock removal
  - Adsorptive iron removal



Model results





Column height 30 cm

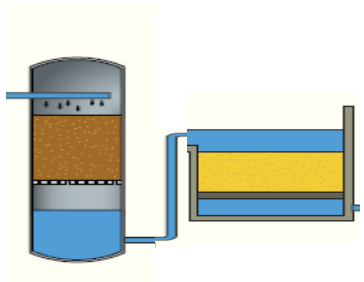
Fe^{3+} influent concentration 0.45 mg/l
Fe^{3+} effluent concentration 0.20 mg/l

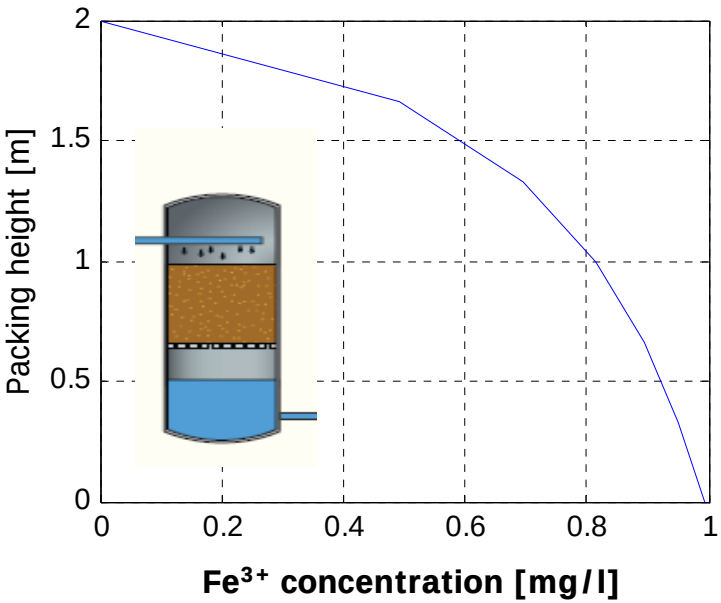
Filter bed height 2 m

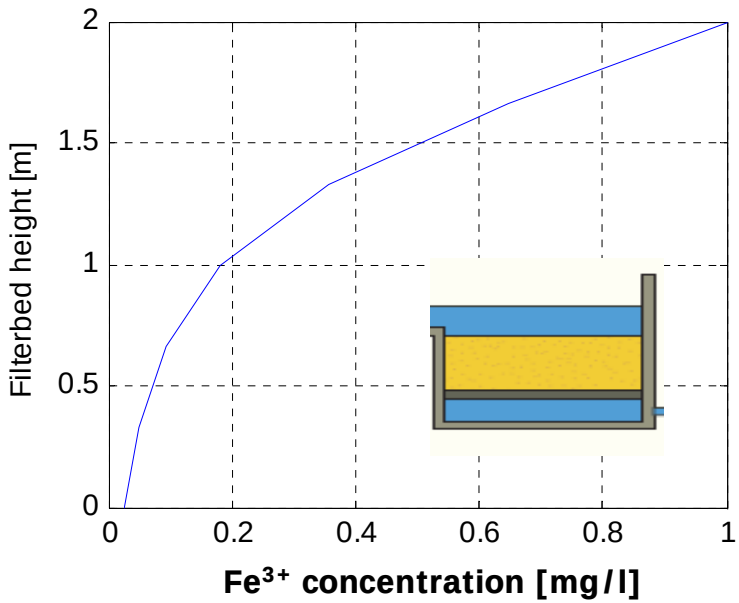
Fe^{3+} effluent concentration 0.033 mg/l

Model results

Tower aeration before filtration:







Fe^{3+} effluent concentration

1 mg/l

Fe^{3+} effluent concentration

0.029 mg/l

CONCLUSIONS
&
RECOMMENDATIONS

Conclusion

Model

- First set-up made for iron removal model
- Quick insight in alternatives

Column experiments

- After cascade aeration the majority of iron is dissolved Fe^{2+}
- At Harderbroek oxidation is limited by the pH

Conclusion

Fingerprint

- Operational events have a significant contribution to volume load
- Relation between ppb's and cleaning frequency

Recommendations

- Apply a smooth treatment operation
- Recirculation of first filtrate after a backwash event
- Guideline 1 ppb?

Alternatives Harderbroek

Replace tower aeration directly after raw water

- More intensive aeration will increase the pH
- No addition of chemicals to the water

Caustic soda dosage

- Easy to implement
- Relatively sensitive to control

Crushed limestone filtration

- Automatic equilibrium, no need for control
- More investment costs, 2 filtration steps

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