Pumping station of Harderbroek

Improving iron removal

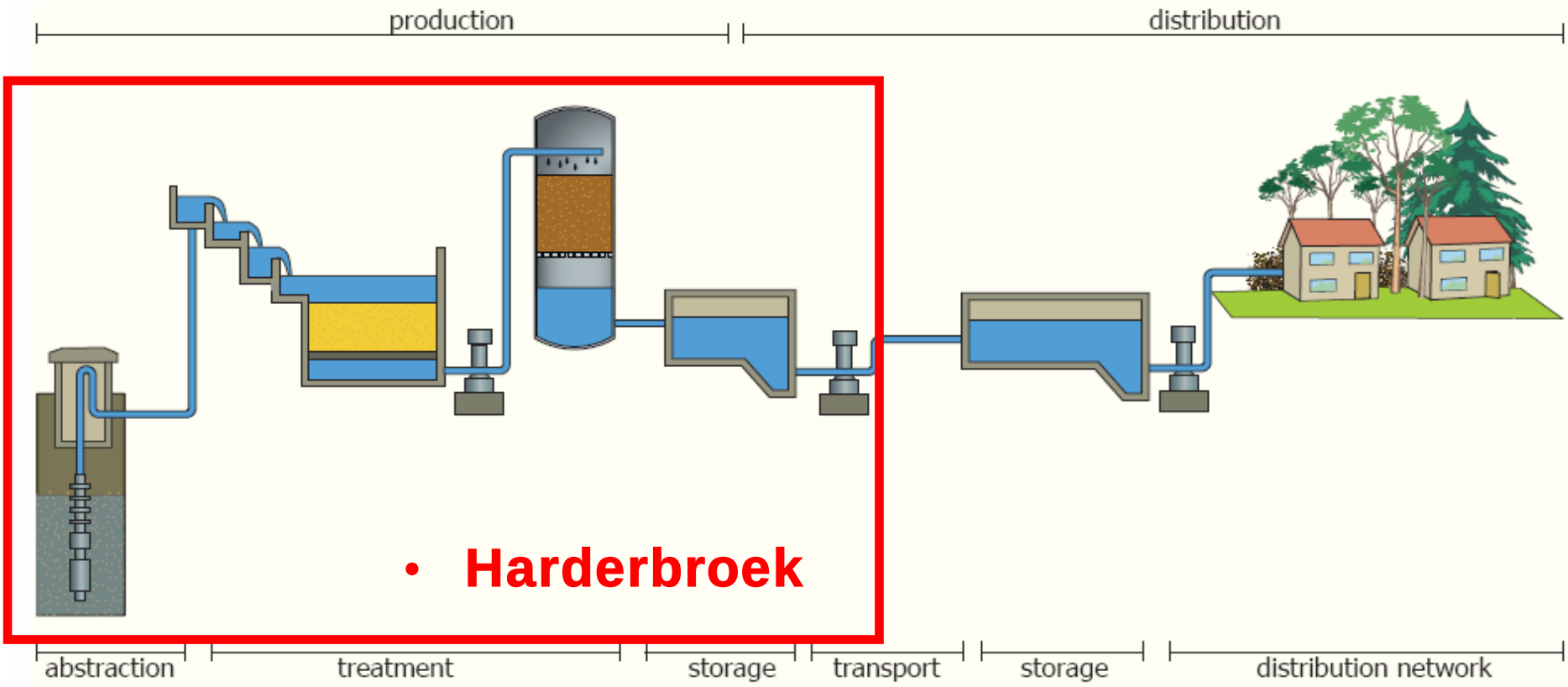
Chiara Di Silvestro Silvia Guerreschi

kiwa
Partner for progress

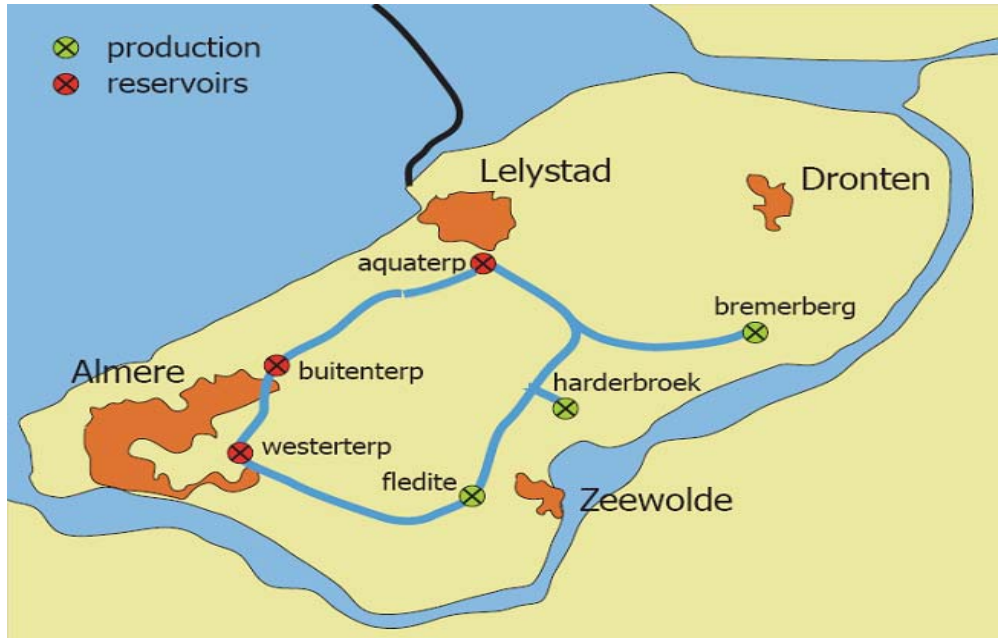
TU Delft

Vitens

Treatment scheme



- Deep wells: necessary because of the geography of the area
- Transport line instead of desalinization
- Good water quality
- Iron and manganese



Dutch drinking water standard for iron = 0,2 mg/l

Recommended value = 0,05 mg/l

Value suggested by Vewin = 0,01 mg/l

Mean value of the water = 0,04 mg/l

PROBLEM DEFINITION

Observed problem → Vitens is not satisfied with the turbidity and the iron concentration of the drinking water. Complains by the costumers.

Cause of the problem → **The oxidation of iron (II) to iron (III) has not a high efficiency because the pH is too low**

$Fe^{2+} \xrightarrow[O_2]{} Fe^{3+} \xrightarrow[Hydrolysis]{} Flock\ Formation$

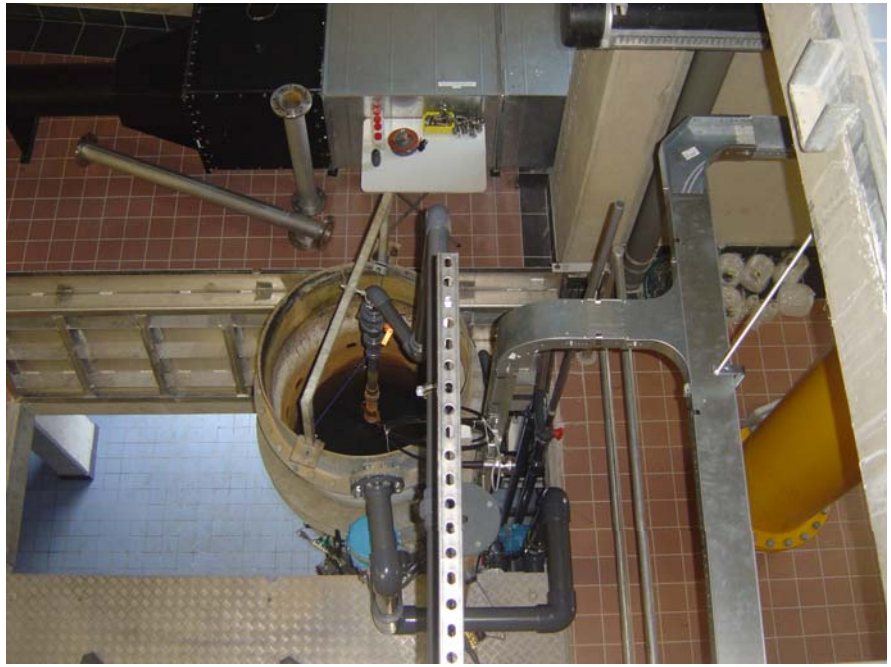
- The rate of conversion increases at an high pH

- The cascades remove CO_2 and increase O_2 → increasing of pH

- The efficiency of cascades is not as high as we want → not all the iron is oxidized

- The tower aeration increases again the pH and this causes the formation of flocks which settle in the distribution system

PILOT PLANT



• Takes the water from the cascades or raw water

• Experiments on filtration

• Parameters are modified through a control panel

TEMPORARY SOLUTION

• Cleaning of the distribution system (high costs)

• Vitens wants to avoid it

Alternatives

1. Improvement of the existing aeration system
2. Changing of the aeration system
3. Addiction of chemicals
4. Crushed limestone filtration
5. Other techniques (Ozonation, Catalytic filtration, Ion exchange)

Improvement of the existing aeration system

Increasing number of steps

The actual number of steps in the cascades is 6

Increasing the number of step an higher efficiency can be obtained

The efficiency of the cascades depends on the fall height of each cascades step and number of steps

Advantages

The simplest solution instead of changing the aeration system: the plant is conserved.

Disadvantages

The efficiency cannot be improved a lot.

Changing of the aeration system

The cascades will be changed with a more efficient system.

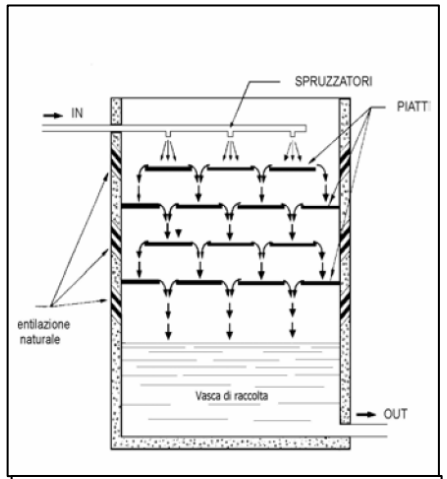
The rising of pH is obtained already after the first aeration system.

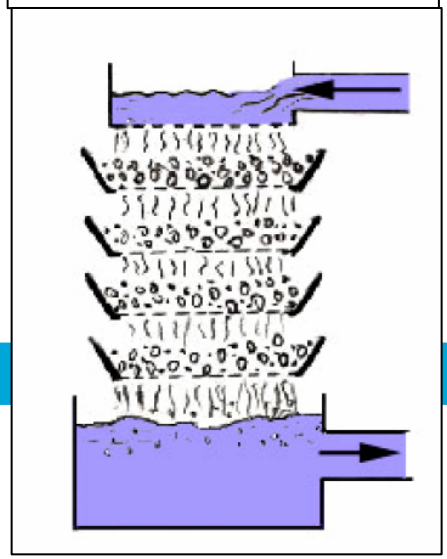
The second aeration system in this case will not be necessary anymore.

- Plate aerator
- Spray aerator
- Tower aerator
- Bubble aeration

Plate aerator

Usually formed by a tower where the water flows over the plates creating a bubble bed of water and air above the plate till the storage pond.





Advantages

Time of contacts very short but high ratio A/V

Disadvantages

Sensitive to clogging because of the smallest orifices

Short-circuits can occur influencing negatively the gas transfer

The plates have to be cleaned once a month or once in two months

Need of aeration system that blows the water from the bottom

Spray aerator

Spray aerators divided water into small droplets which results in a large air-water interface

Advantages

Easy to incorporate into existing installation: can be placed directly above the filter

Disadvantages

High sensitivity to clogging

Bubble aerator

Bubble aerators are open tanks in which the air in pressure is blown through holed tubes, plates of porous materials, candles…

Advantages

• Smaller space than the spray aerators (even if it is bigger than the gravity aerators)

Disadvantages

• The contact time is higher than the gravity aerators

• The ratio A/V is smaller and the results are worse

Tower aerator

A tower aeration consists of a cylinder of steel or synthetic material that is filled with a packing medium. Because of this a large contact surface between the air and the water is created for gas transferred.

Advantages

- The efficiency can be as high as 95%
- It already exists in the treatment scheme

Disadvantages

- Sensitivity to clogging (necessary to back flush the tower aeration)

Adding of chemicals

It consists of dosing caustic soda into the water in order to rise the pH.

Advantages

- The pH is succesfully increasing
- No relevant changes in the plant → we just need a pump and a stock vessel

Disadvantages

- The flocks of iron (III) hydroxide are very small → they can break through the filter
- Chemicals are possibly avoided
- It is necessary to build a disposal system for by-products

Crushed limestone filtration

- Changing of the hydraulic line scheme:

Cascade aeration → Crushed limestone filtration → Tower aeration → Rapid sand filtration

- Decreasing of CO_2 → increasing of pH

$$CaCO_3 + CO_2 + H_2O \longrightarrow Ca^{2+} + 2HCO_3$$

Advantages

- No need to build other part of the plant
- No need for operation
- The pH is steadily high (8)
- No aeration at the end of the treatment

Disadvantages

- The particle load can increase
- The grains have to be replaced

OTHER TECNIQUES

Ozonation

Used instead of O_2 because of its greater oxidizer potential

Ozone injection → Contact time tank → Filter

Advantages

- The convertion from iron (II) to iron (III) is more efficient

Disadvantages

- Ozone has to be producted (costs)
- Possible by-products
- Storage problems

Catalytic filtration

It enhances the reaction between O2 and iron (II), then it filters the iron (III) that has been formed

Ion exchange

It removes soluble iron (II)

FINAL DECISION

Crushed limestone filtration

- The treatment scheme is different but there is no need to change the plant
- 8 filters → 4 are used for crushed limestone filtration
  → 4 are used for rapid sand filtration
- The actual capacity of each filter is the half of the possible capacity for which they have been designed
- The size of the grain in the rapid sand filtration can be smaller and guarantee a better final water quality
- Better to end the treatment with a filtration than an aeration
- The water reaches the optimal value of pH of 8
- The surface load will be lowered compared to the surface load of the present rapid sand filtration step because of the previous filtration.

QUESTIONS?