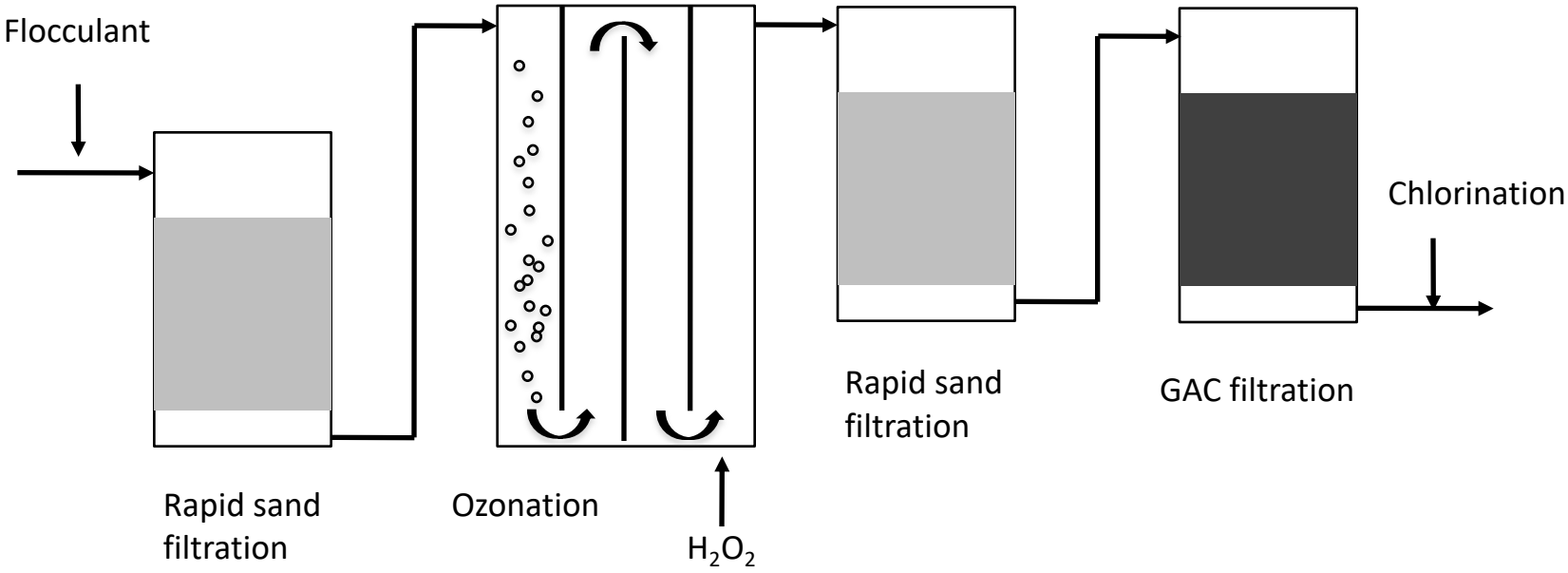
Water type 1

Parameter	Measured value
Temperature	7-12ºC
pH	6.4-7.1
DOC	1-5 mg/L
UV (254 nm)	1.3-19.5 m^{-1}
Calcium	122 mg/L
Magnesium	3.5 mg/L
Nitrate as $NO3^-$	25 mg/L
Atrazine	150 ng/L
Tetrachlorethylene	20 µg/L
Trichlorethylene	15 µg/L
Bromide	20 µg/L
Turbidity FTU	0.2 - 150

Treatment of karstic water Porrentruy



Water type 2

Parameter	Measured value
Temperature	11.4°C
pH	7.1
DOC	4 mg/L
Total Hardness °F	39
Calcium Hardness °F	35
Magnesium Hardness °F	3.9
Oxygen	0 mg/L
Nitrate as N	< 0.01 mg/L
Nitrite as N	0.02 mg/L
Ammonium as N	1.2 mg/L
Iron	6.6 mg/L
Manganese	0.22 mg/L

Pump and treat: Reduced Groundwater Alpnach

Chemical treatment

Iron removal: Aeration – precipitation – sedimentation – filtration. During this process, there will also be partial nitrification and manganese removal.

Ammonia: Break point chlorination or nitrification. Break point chlorination is not favored anymore, because of the high chlorine demand (Breakpoint: Cl_2:NH_4^+ = 1.5, 1.05×10^{-4}M Cl_2 would be required ≈ 7 mg/L!). Nitrification is the preferred process.

Manganese removal: It can be expected that Mn(II) will not be fully removed by oxygenation of the water. Therefore additional treatment with a stronger oxidant is required. Permanganate may be a good choice.

Biological treatment

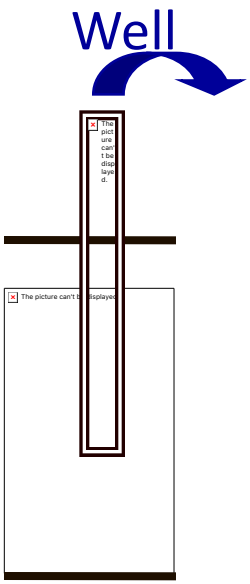
Biological iron and manganese removal

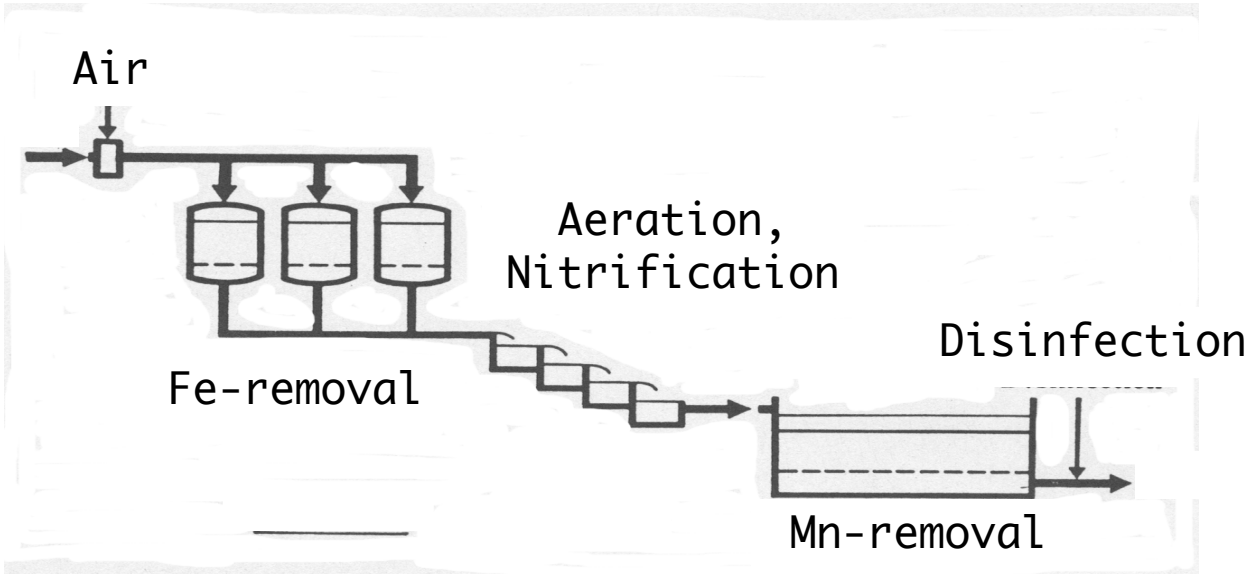
1. Ground water is pumped from the aquifer

2. Oxidation of Fe(II) and/or Mn(II) in separate steps

Fe(III)OOH, $Mn(IV)O_2$

3. Separation of the hydroxide sludges





Chemical treatment

Chemicals: O_2, O_3, Cl_2, ClO_2, $KMnO_4$, Base

Biological treatment

Oxidizing microorganisms, O_2

In situ treatment:

The yield can be calculated as follows:

In a first approximation only ammonia and iron have to be considered for oxygen consumption.

1 mol of NH_4^+ consumes 2 moles of oxygen (nitrification); $[NH_4^+]$ = 1.2 mg/L = $7x10^{-5}$ M => $1.4x10^{-4}$ M oxygen.

1 mol of Fe(II) consumes ¼ moles of oxygen; [Fe(II)] = 6.6 mg/L = $1.17x10^{-4}$ M => $2.9x10^{-5}$ M oxygen.

In total, $1.69x10^{-4}$ M oxygen are consumed for the removal of ammonia and iron(II).

The oxygen concentration of injected water is 8 mg/L = $2.5x10^{-4}$M.

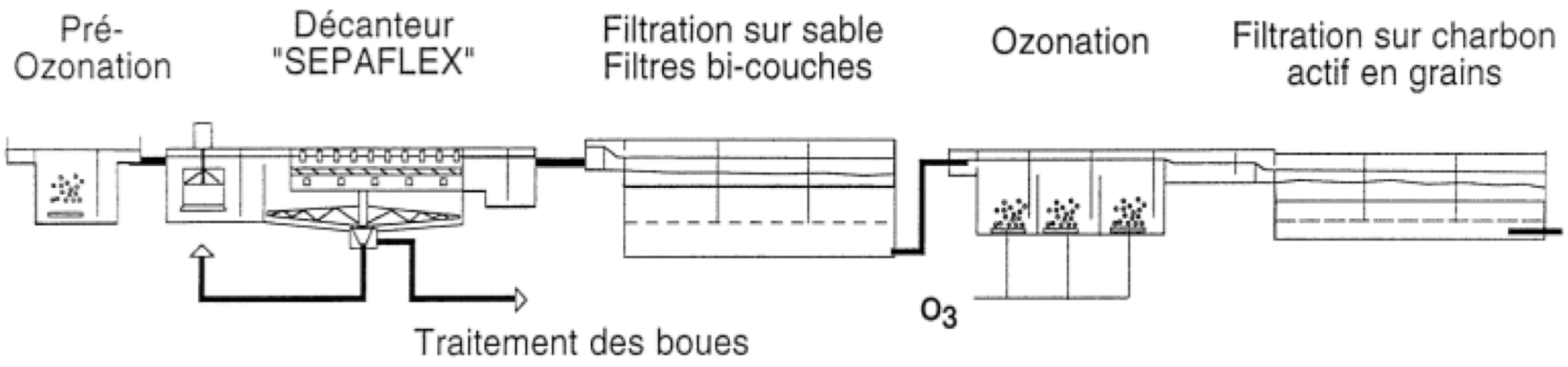
Therefore the yield of this system would be about 1.5 (only 1.5 x more water can be extracted than what was injected) which is too small to make the process economically feasible.

If no ammonia would be in the water, the ratio of extracted/injected water would be about 10.

Water type 3

Parameter	Measured value
Temperature	11 - 25 ^{o}C
pH	7.5 - 8.4
Turbidity FTU	2.3-60
DOC	7.9 - 20 mg/L
Taste and odor	intense
Total Hardness German ^{o}H	15 - 20
Carbonate Hardness German ^{o}H	9 - 12
Oxygen	7 - 17 mg/L
Chloride	30 - 160 mg/L
Bromide	0.05 - 0.2 mg/L
Iron	0.05-0.47 mg/L
Manganese	0.06-0.21 mg/L

Treatment of Warnow river water



Pre-ozonation

Sedimentation

Rapid sand
Filtration
2-layers

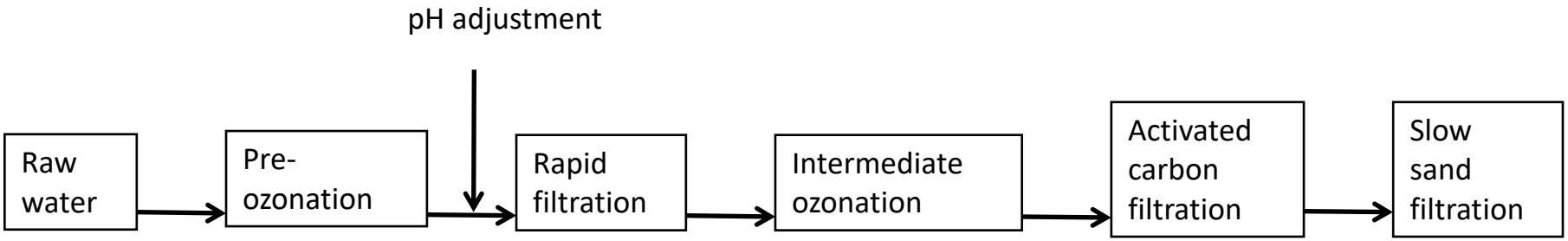
Ozonation

Granular activated
carbon filtration

Water type 4

Parameter	Measured value
Temperature	4 - 8 °C
pH	7.8
DOC	1.2 mg/L
Calcium hardness	1.2 mM
Total hardness	1.5 mM
Carbonate hardness French °H	9 - 12
Oxygen saturation	60 - 98 %
Chloride	3 mg/L
EDTA	1 - 3 µg/L

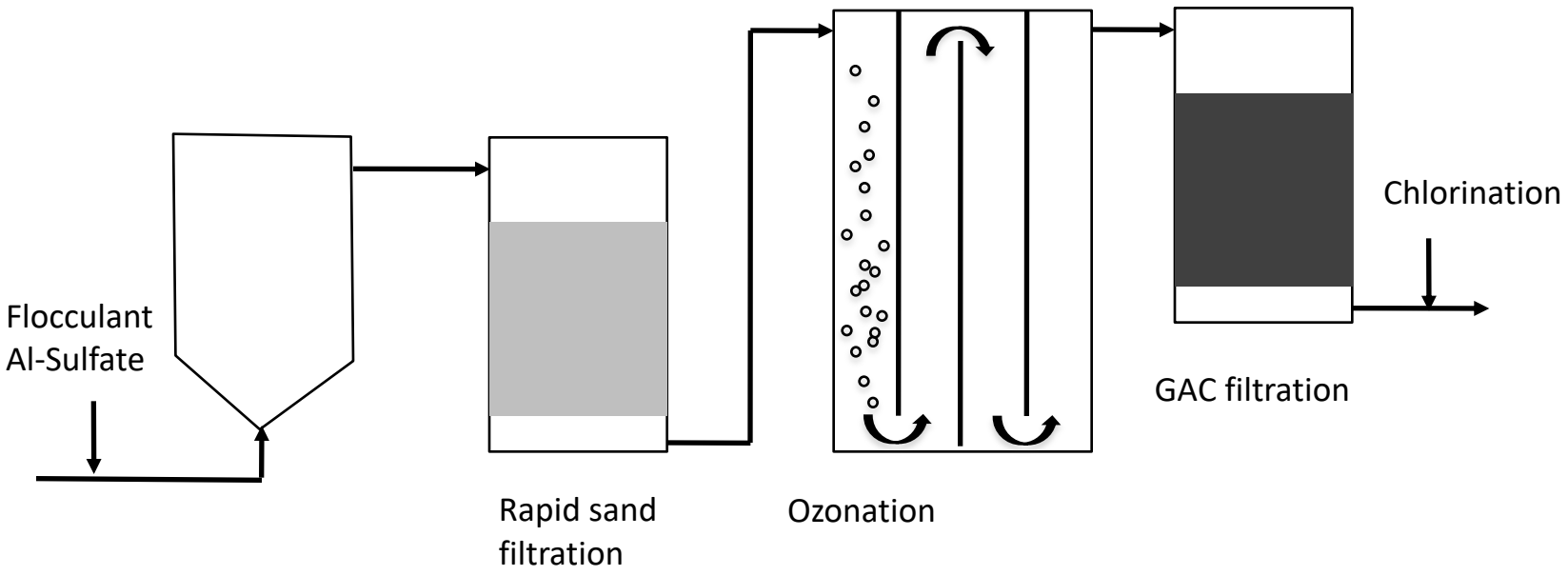
Lake water treatment plant Lengg, Zürich



Water type 5

Parameter	Measured value
Chloride mg/L	6.30
Enterococci /100 mL	25-300
Escherichia coli /100mL	42-200
Fluoride mg/L	0.05
Taste and odor	-
Total Hardness °F	28.40
Nitrate mg/L	20.90
pH	7.14
Oxygen mg/L	9.35
Oxygen saturation %	87.20
Turbidity FTU	0.2-10
Temperature ^{o}C	10-15

Treatment of karstic water Canton Baselland 1



Treatment of karstic water Canton Baselland 2