EXPO AGUA PERÚ 2019

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Sustainable Solutions for Wastewater Treatment

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Goals of a sustainable water management

- Use of limited water resources should be sustainable
- Water supply has the highest priority
  - Qualitative requirements
  - Quantitative requirements
  - Monetary claims
  - Sustainable implementation
  - Robust and reliable techniques
  - Minimal, if possible, no impact on the environment

- Wastewater treatment and removal
  - For hygienic reasons wastewater must be quickly removed from settlements
  - Wastewater Treatment aims for removal (of carbon/nitrogen/phosphorus compounds) and hygienisation
  - Wastewater should not negatively affect people and environment

Challenges for sustainable water management

- Water resources are often extensively used in water scarcity regions (consumption >> supply)
  - Exploited sources are groundwater and surface water
- Many different users and actors are involved
  - Consumers
  - Stakeholders
  - Nature & environment

- Planning processes often have to be carried out based on insufficient data basis

Tools & methods for achieving the goals

- Which data is required and available for planning?
- Which potential users for reclaimed water are available?
- What water qualities are required?
- Which technology can clean wastewater and transform it into reclaimed water?

Which water qualities are required?

- Drinking water quality:
  - mainly in residential areas,
  - in (food) processing industry,
  - industry in general
- Irrigation water:
  - mainly for agriculture,
  - nurseries,
  - city/community,
  - environmental system services,
  - private properties
- Effluent of WWTP:
  - water bodies such as rivers, lakes, sea
- Service water quality:
  - mainly from industry & commerce, the requirements must be considered case-specifically → is not considered here...

What wastewater qualities are due?

- Municipal wastewater
  - mixture of blackwater (faeces, urine, rinsing water) and greywater (from kitchen, bathroom)
  - Wastewater from small businesses, handicrafts, public administration
  - Wastewater from processed (small) businesses, e.g. slaughterhouses, bakeries, etc.

- Industrial wastewater
  - Wastewater from administration, toilets, etc.
  - Cooling water
  - Rinsing and cleaning water
  - Production wastewater (differs greatly from each other)

Which data is required and available for planning?

- The more, the better…

- 1st Priority: Check the Site!
- 2nd Priority: Measure yourself!
  - Old data can be outdated due to significant changes
  - Data quality can differ
  - How were the samples taken? Who took the samples?
- 3rd Priority: Fill in the gaps!
  - Only if data is not available or cannot be measured
  - Try to make a reasonable assumption

Comparison of data quality: grab samples vs. 2h mixed samples

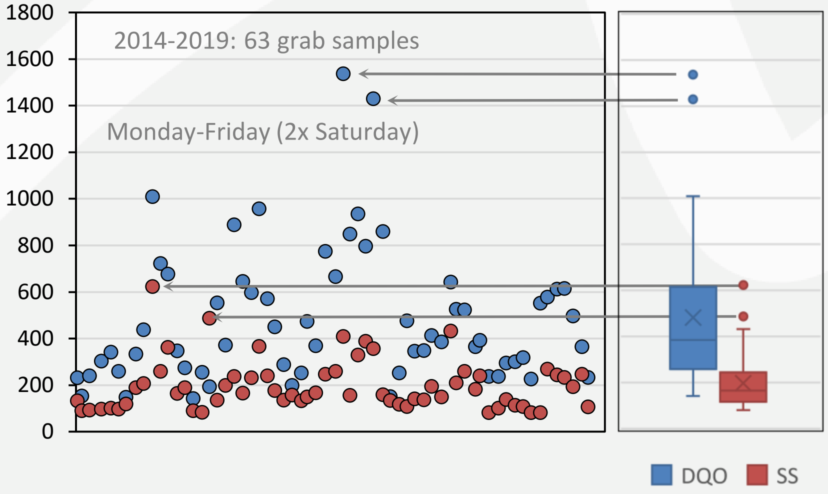
Grab samples

- Only taken once
- No statement about daily fluctuations
- Depending on the WWTP size hydraulic retention of wastewater is less than 24 h.

2h mixed samples

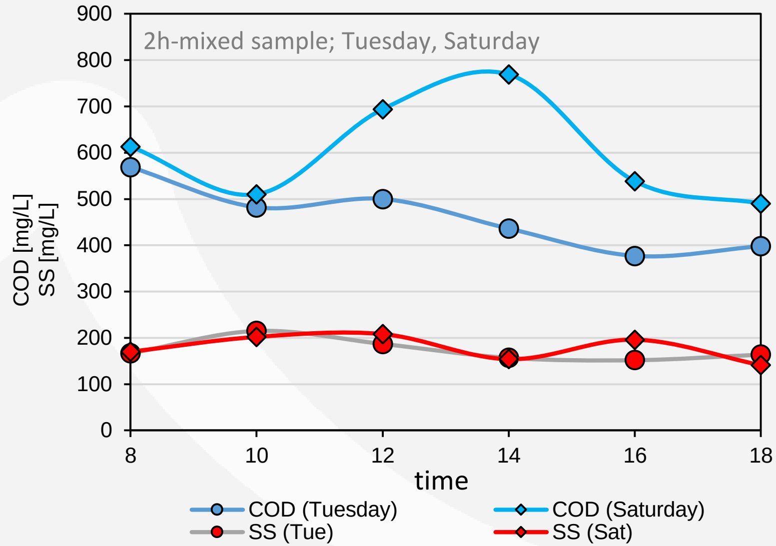
- 5 samples within 2h equally mixed
- no statement about seasonal fluctuations

Comparison:
Data quality of grab samples vs. 2h mixed samples



DQO (85%): 758 mg/L; SS (85%): 265 mg/L
DQO (avrg.): 482 mg/L; SS (avrg.): 198 mg/L

Shock load? Daily variation?



DQO (85%): 713 mg/L; SS (85%): 204 mg/L
Shock load DQO: Factor 1,3

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Which technology can clean wastewater and transform it into reclaimed water? – technical suggestions

- Physical cleaning processes
  - Screening, sedimentation, flotation
- Chemical cleaning processes
  - Precipitaiton/flocculation,
  - Oxidation, reduction
- Biological cleaning processes
  - plants
  - bacteria
  - algae
  - fungi
  - ....

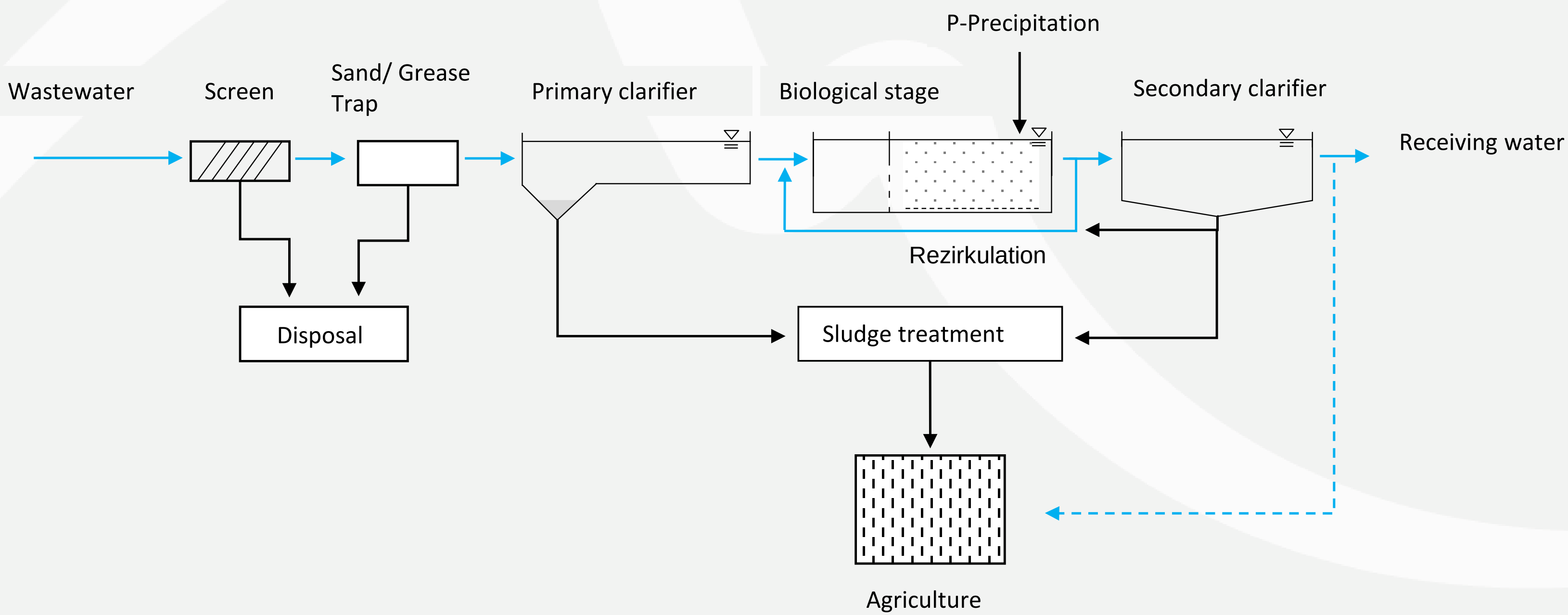
→ Slow sand filtration (3)

→ Nutrient removal (1-3)

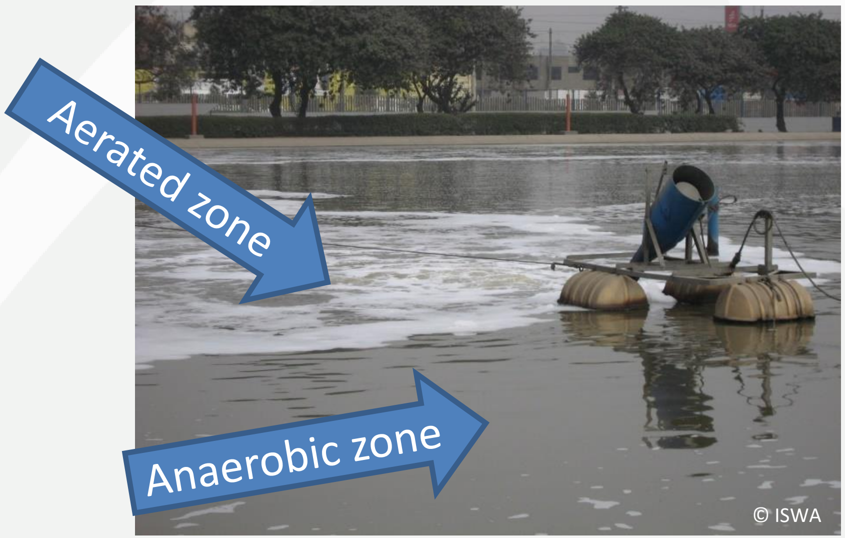
→ Activated sludge process (1)

→ Trickling filter (2)

(1) Activated sludge process



(1) Biological treatment with aerated ponds



insufficient oxygen supply due too few aerators; O_2 <2 mg/L

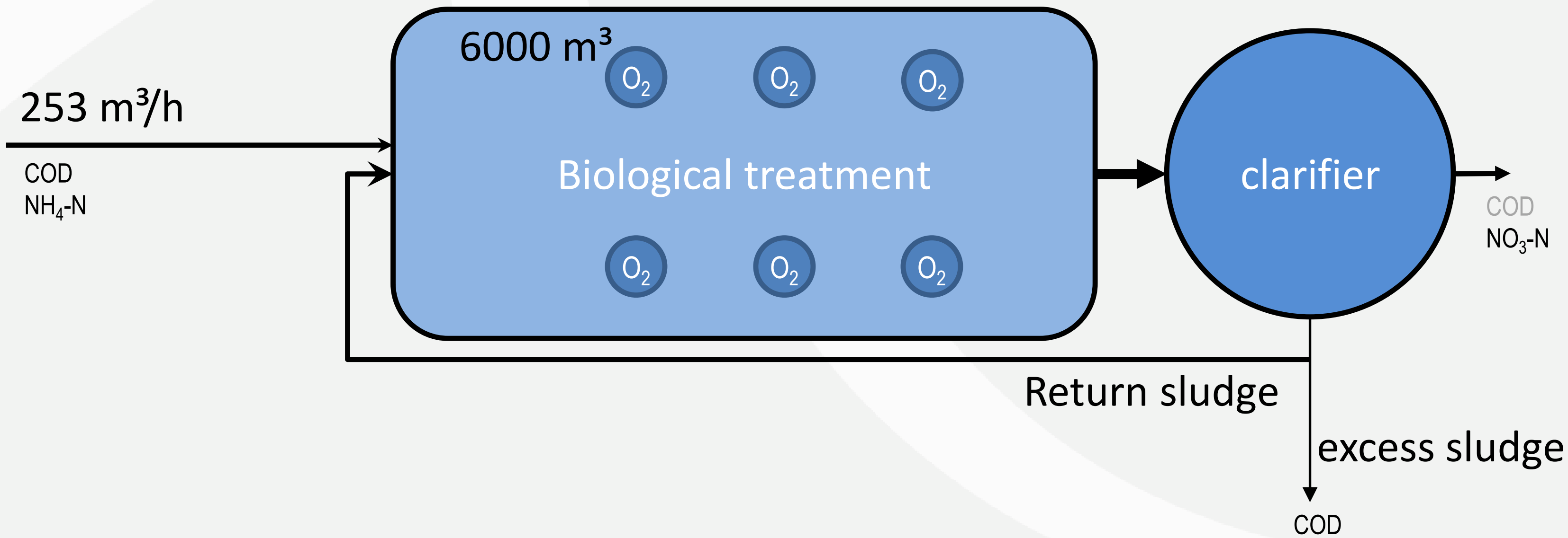
(1) Biological Treatment with activated sludge system

oxygen supply with diffusers; O_2 >4 mg/L

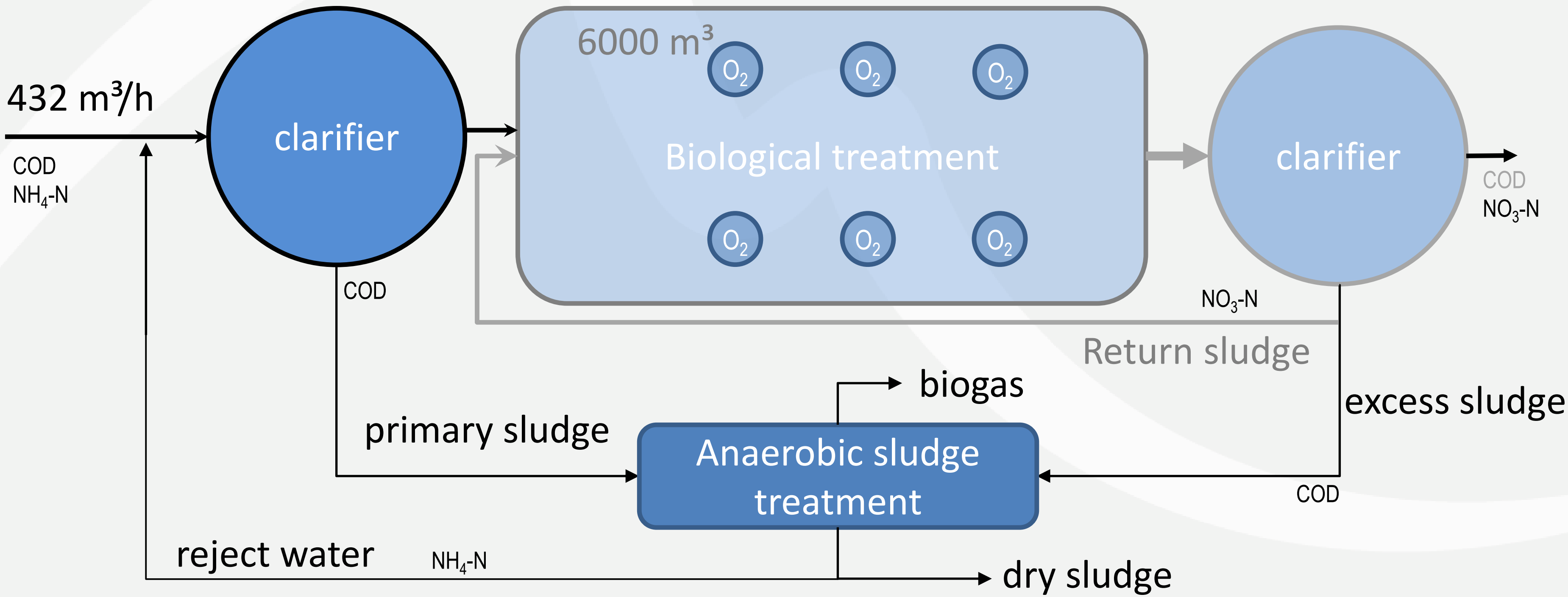
Improving the performance of WWTP

- Primary clarifier:
  - separation of primary sludge (50% COD removal; 50% SS removal);
  - utilisation in anaerobic digestor for biogas production (~50% of energy demand can be covered)
- Using membrane diffusers for oxygen supply:
  - better performance in terms of oxygen dissolution
- Denitrification:
  - use nitrate for COD-removal (recycle nitrate to pre-denitrification)

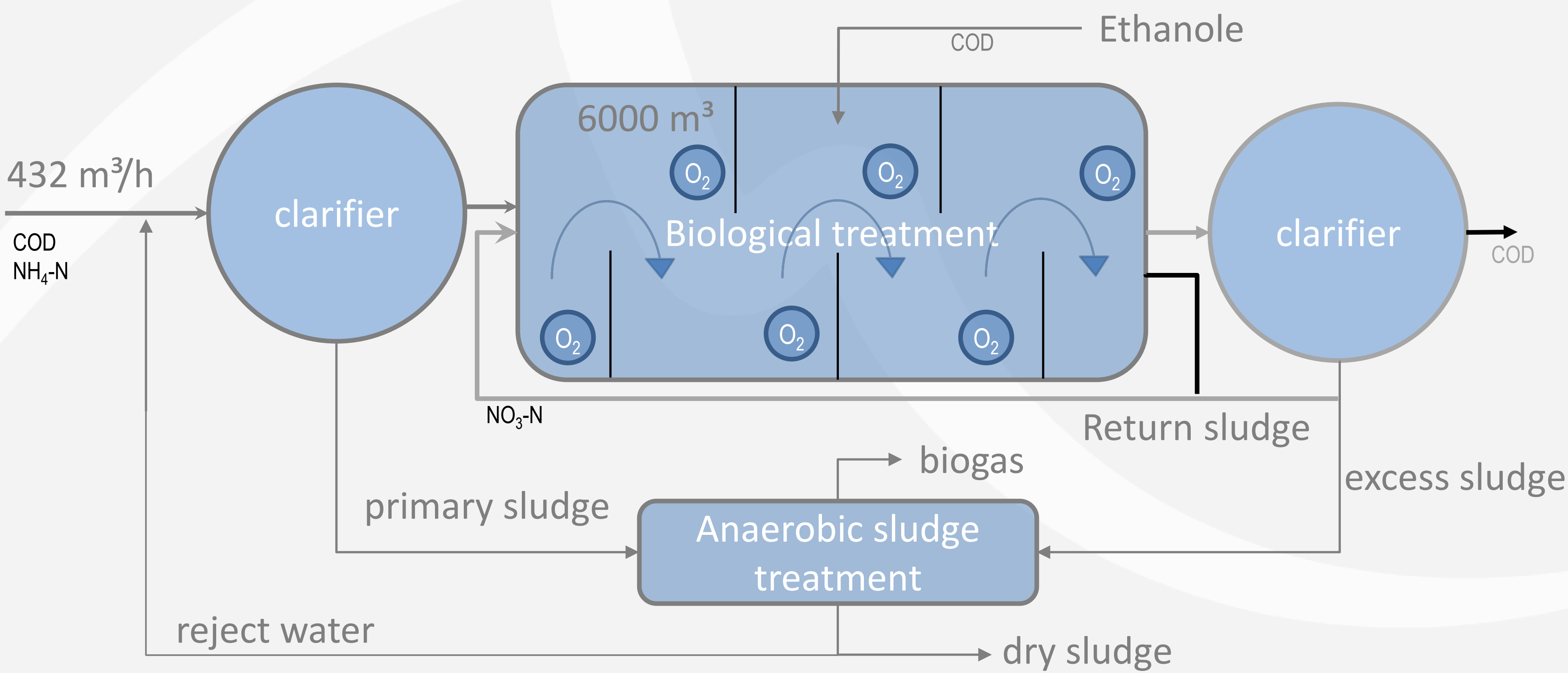
Case Study: Upgrading an existing WWTP



Upgrade I: primary clarifier + anaerobic sludge treatment



Upgrade II: denitrification + (indirect) re-use options



Expected effluent quality

Parameters*	Influent	Influent	Effluent	Effluent	Effluent
	Measured by ISWA	Grab samples (n = 63)	existing WWTP (according to german design rules – A131)	Upgrade I: Primary clarifier + anaerobic sludge treatment	Upgrade II: Nutrient removal + reuseability
Q_in [L/s]	70,3	77	70,3	120	120
COD [mg/L]	713	758	50	50	50
SS [mg/L]	204	265	<l.o.d.	<l.o.d.	<l.o.d.
TN [mg/L]	76	-	57	69,6	6,8
NO_3-N [mg/L]	-	-	55	67,6	~27 (6,8**)
P [mg/L]	8	-	4,4	4,7	0,5
V_biological treatment [m³]	-	6000	1200	1500	5000
Oxygen demand [kg O_2/d]	-	-	1760	5000	4600 (+ 0,8 m³ Ethanole)
Primary sludge/secondary sluge [kg oTS/d]			- / 2000	1040/2550	1040/2200
Energy (biogas, 60% CH_4) [m³/d]				~1400	~1300

* 85-percentile; ** with additional Ethanole

(2) Concept: Tricklingfilter

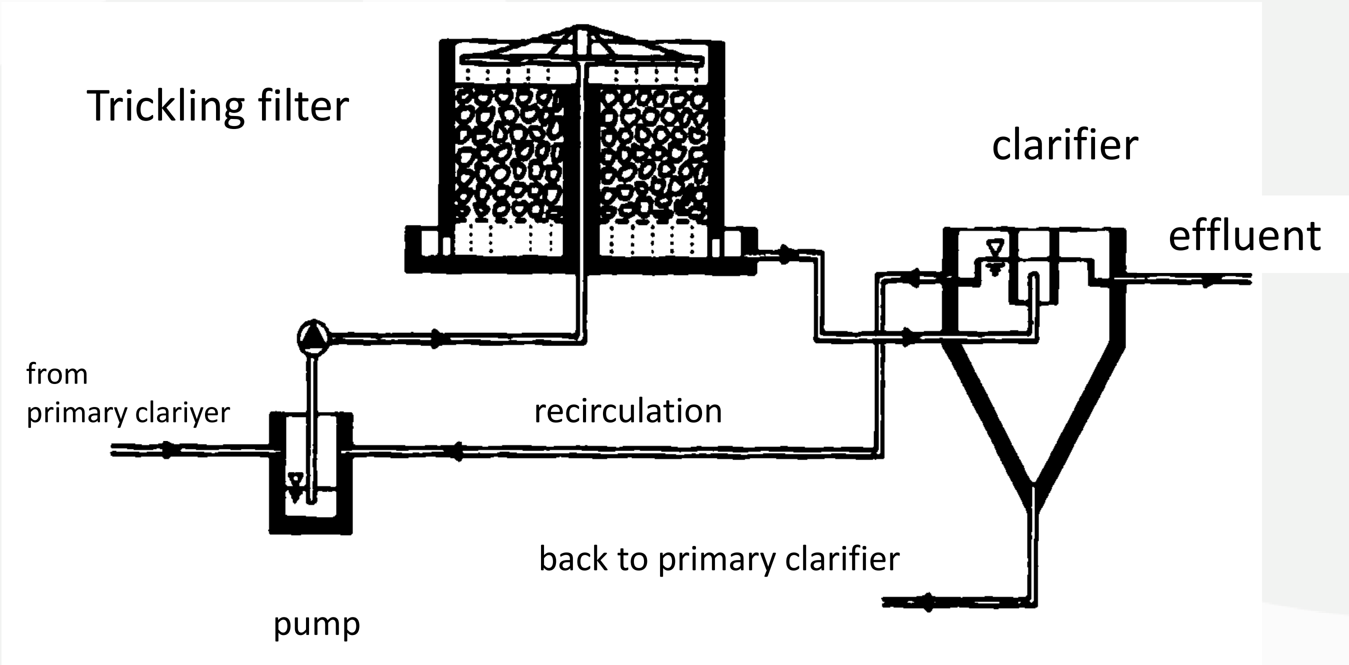
Topview of a trickling filter filled with lava rocks (Sindelfingen, Germany)

Filter material:

Lava rocks,
Plastic profiles etc.

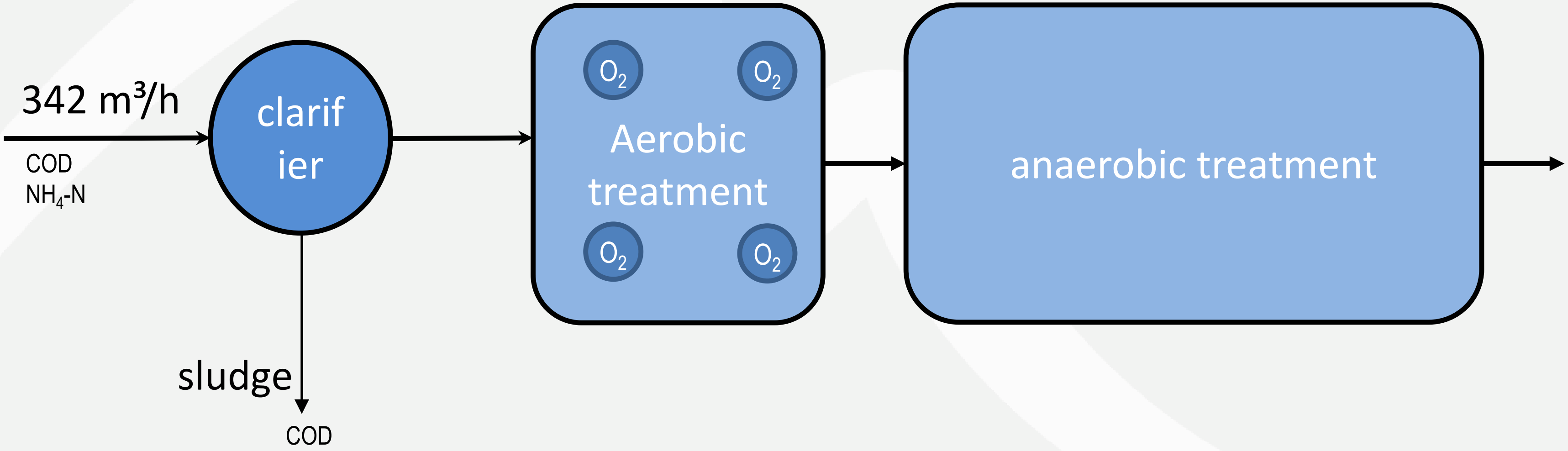
Topview of a trickling filter with plastic profiles

(2) Concept: Tricklingfilter

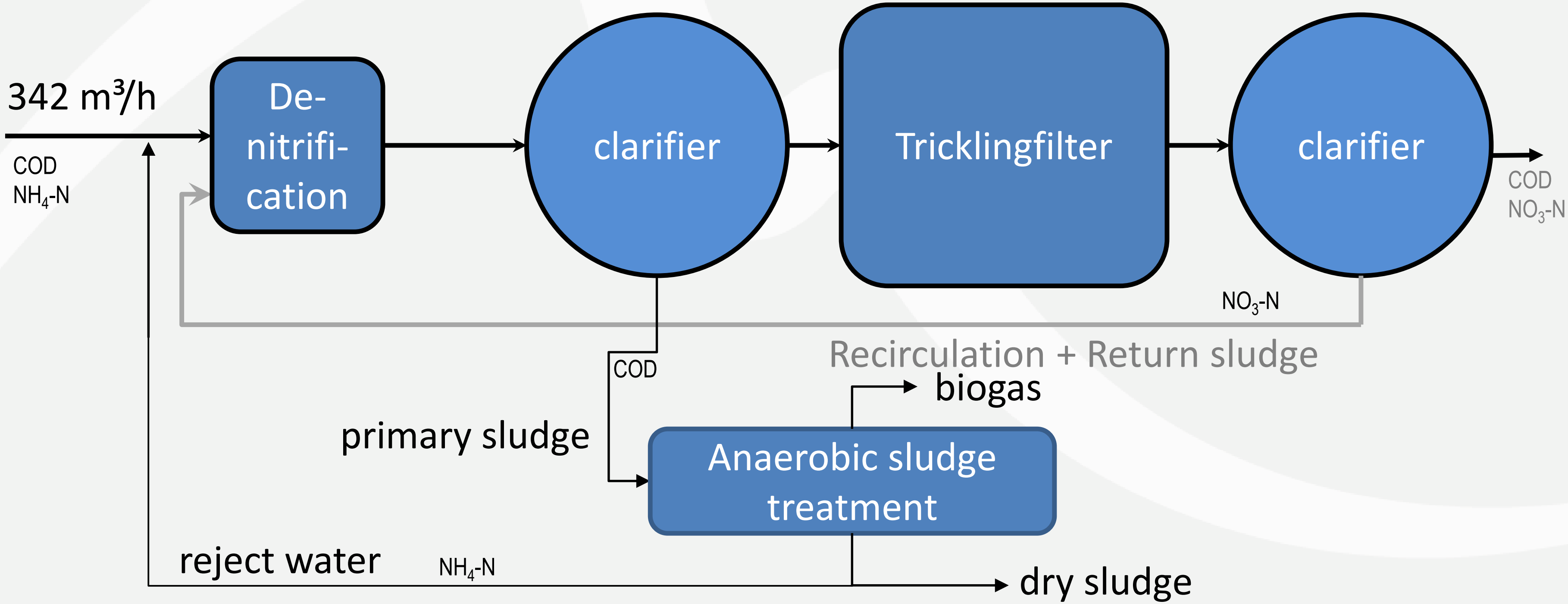


Mudrack und Kunst (2003): „Biologie der Abwasserreinigung“

Case Study: Upgrading an existing WWTP



New process design:



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Expected effluent quality

Parameters*	Influent	Influent	Influent	Effluent
	Measured by ISWA	Grab samples (n = 38)	Design values	for Trickling Filter
Q_in [L/s]	90	64,4	90	90
COD [mg/L]	713	1394	1394	85
SS [mg/L]	566	582	582	<l.o.d.
TN [mg/L]	161	-	161	6
NO_3-N [mg/L]	-	-	-	4
P [mg/L]	8	-	8	2
V_Trickling filter [m³]				8300
Recirculation factor				7,9 (=90 L/s x 7,9 = 711 L/s)
Primary sludge/ secondary sluge [kg oTS/d]				2700 / 2500
Energy (biogas, 60% CH_4) [m³/d]				~2100

- V_DN = 3200 m³
- V_PC = 3200 m³
- V_SC = 3200 m³
- 4 Trickling filters (23 m diameter, 5 m height)

Drawback:

To achieve the effluent quality a lot of wastewater has to be recirculated (711 L/s + 90 L/s inflow).

(3) Slow Sand filtration: polishing reclaimed water

Slow Sand filters in India

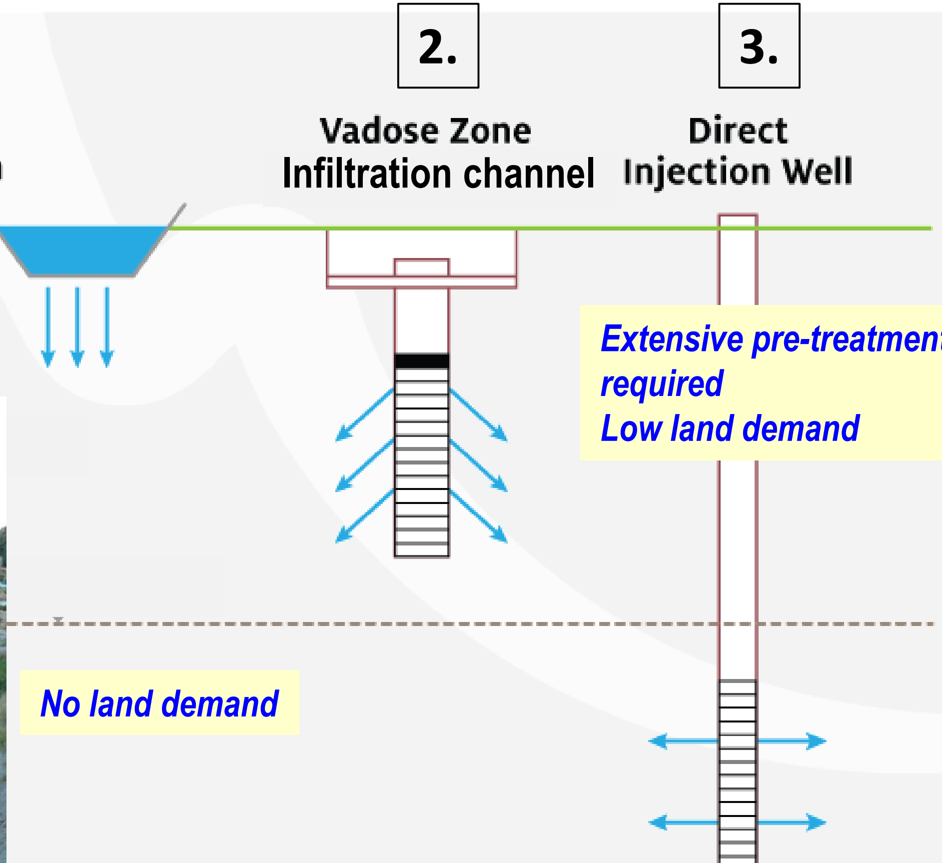
Expected effluent quality of slow sand filters

Parameters	Influent	Effluent
	Measured by iswa	
Q_in [L/(m² h)]	300	300
NH_4-N [mg/L]	0,30	0,01
NO_3-N [mg/L]	11,1	11,6
NO_2-N [mg/L]	0,14	0,06
COD [mg/L]	15	12
Turbidity [NTU]	0,55	0,15
Coli. Bacteria [MPN/100mL]	119	1
Clostridium perfrigens [CBU/100mL]	10	0
Somat. Coliphages [PFU/100mL]	2	1

Possibilities of infiltration

Low requirements for the quality of infiltrate

100 L/s ~10.000 m²



Extensive pre-treatment required
Low land demand

4.

River management

No land demand

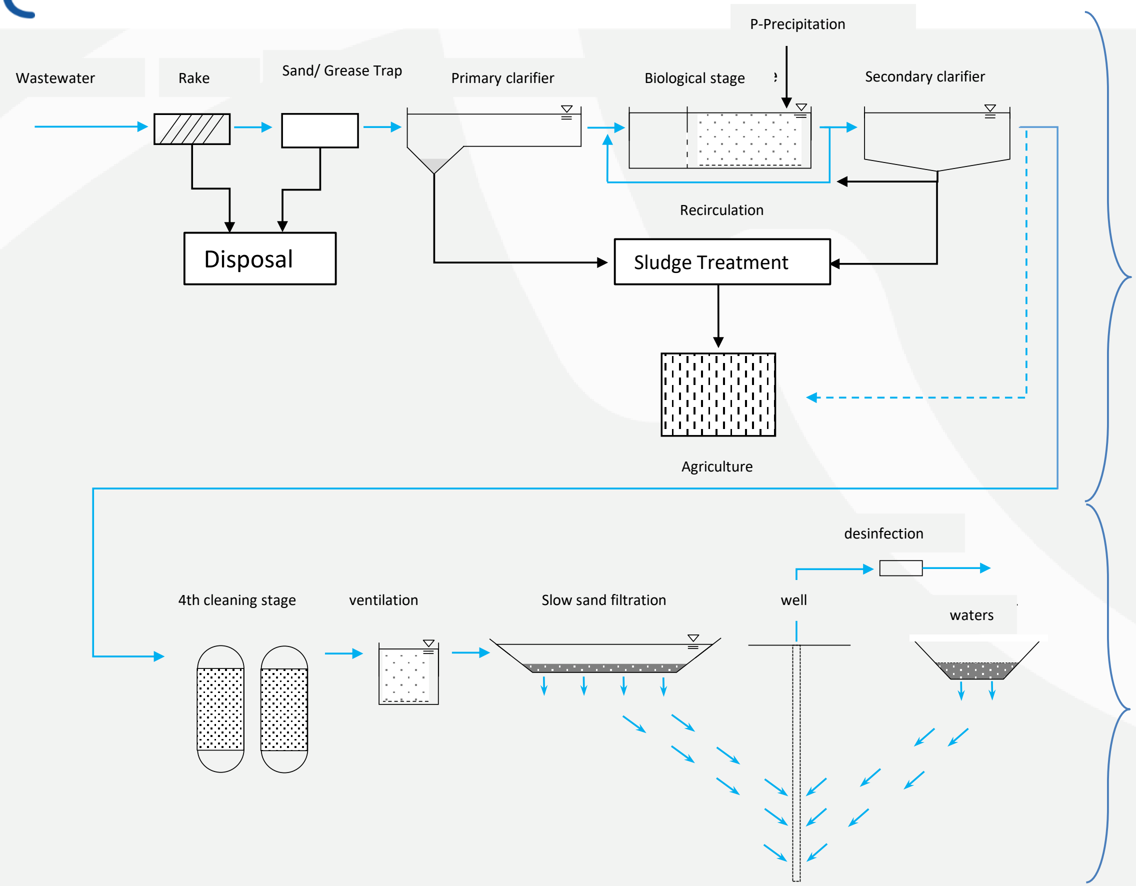
Proposal: Quality for aquifer recharge

Parameter	Unit	injection recharge well	recharge basins	
Turbidity	NTU	0.1	2	US EPA 2012
Escherichia coli	KBE/100 ml	0	1000	Vilanova et al. 2013
TOC	mg/l	1	10	Vilanova et al. 2013
Nitrogene, total	mg/l	10	10	EU UWWTD 1991
Sulfate	mg/l	150	150	Vilanova et al. 2013
Lead	mg/l	0.0012	0.0012	LAWA 2016
Biozides, total	mg/l	0.0005	0.0005	LAWA 2016

Injection wells:
Water quality requirements rather high. Advanced treatment (e.g. RO, O_3/BAC) necessary

Recharge basins:
„Conventional" waste water treatment sufficient

Overall process



wastewater treatment

soil aquifer treatment

Summary & Conclusion

- Water is a limited and (over-)exploited commodity. Many different users demand different water qualities → reclaimed water can be a solution.
- Sufficient data for planning is often scarce. → check the site, measure yourself, fill the gaps
- Wastewater treatment must be done with suitable technologies, e.g.
  - Primary sedimentation tanks (solids removal)
  - Activated sludge process
  - Tricklingfilter process
  - Desinfecction (e.g. by slow sand filtration)
  - Sludge treatment e.g. by anaerobic treatment
- Treated wastewater (reclaimed water) is a valuable commodity

trust

Thank you very much!

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