Lecture 17

Wastewater Treatment in Rurally Structural Areas

Small sewage treatment plants (values up to 50 total number of inhabitants)

DIN standard 4261:

The following may not be discharged into small sewage treatment plants :

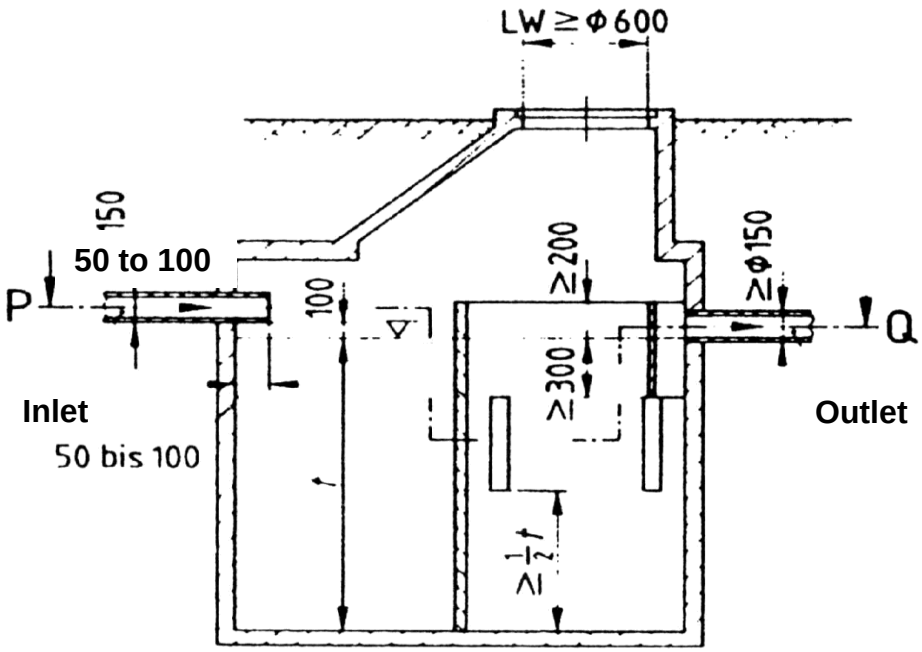
- **Commercial wastewater** so far as it is not comparable with domestic wastewater
- **Infiltration water** (e.g. drainage water)
- **Cooling water** and discharged water from **swimming pools**
- **Precipitation water**

Three-compartment septic tank

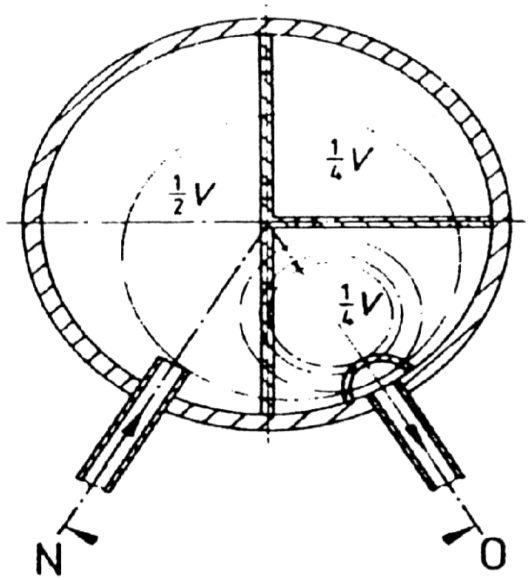
- Utilisable volume: 1500 litre per inhabitant
  (in multi-compartment settling basins: 300 litre)

- Minimum total volume of 6000 litre
  (in multi-compartment settling basins: 3000 litre)

Section N – O



Section P – Q



Process variants of small sewage treatment plants

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Downstream biological treatment process variations

Purification in	Process
the soil body	Absorbing well Subsurface watering Filter ditch
the water body (technical methods)	Trickling filter Submerged contact aerator Activated sludge reactor
the water body (pond methods)	Wastewater lagoons/ponds
the soil and water body	Constructed wetlands

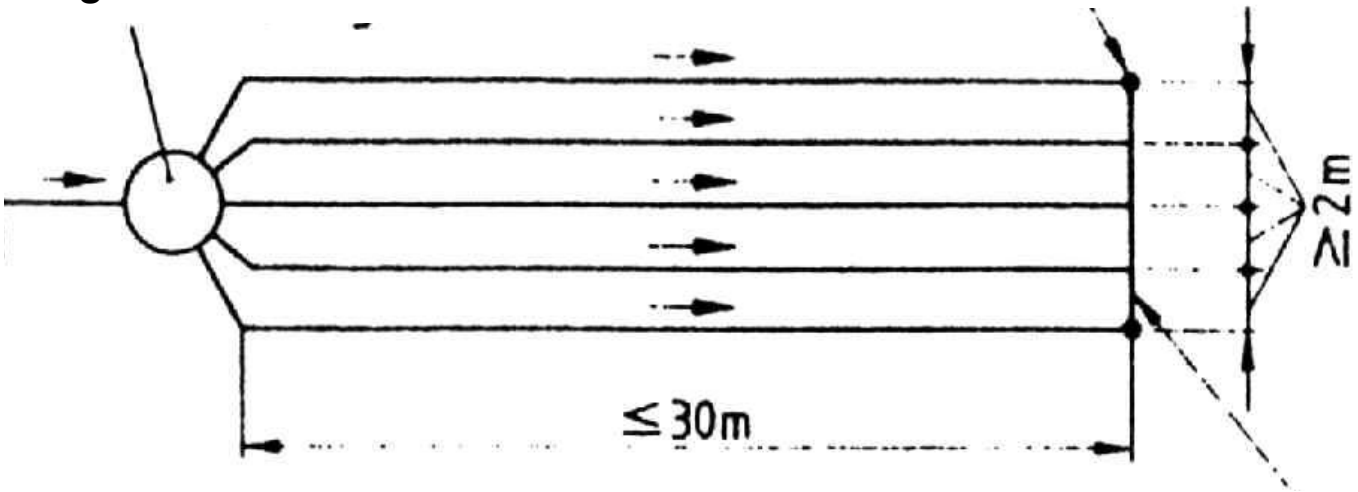
The process of subsurface watering is no longer used for new plants!

Subsurface watering and drainage

If possible:
- intermittent loading
- pipes made of clay or plastics
- operating time/functional efficiency according to the soil 5 - 20 a

Distribution chamber if necessary with equipment for intermittent loading

Ventilation

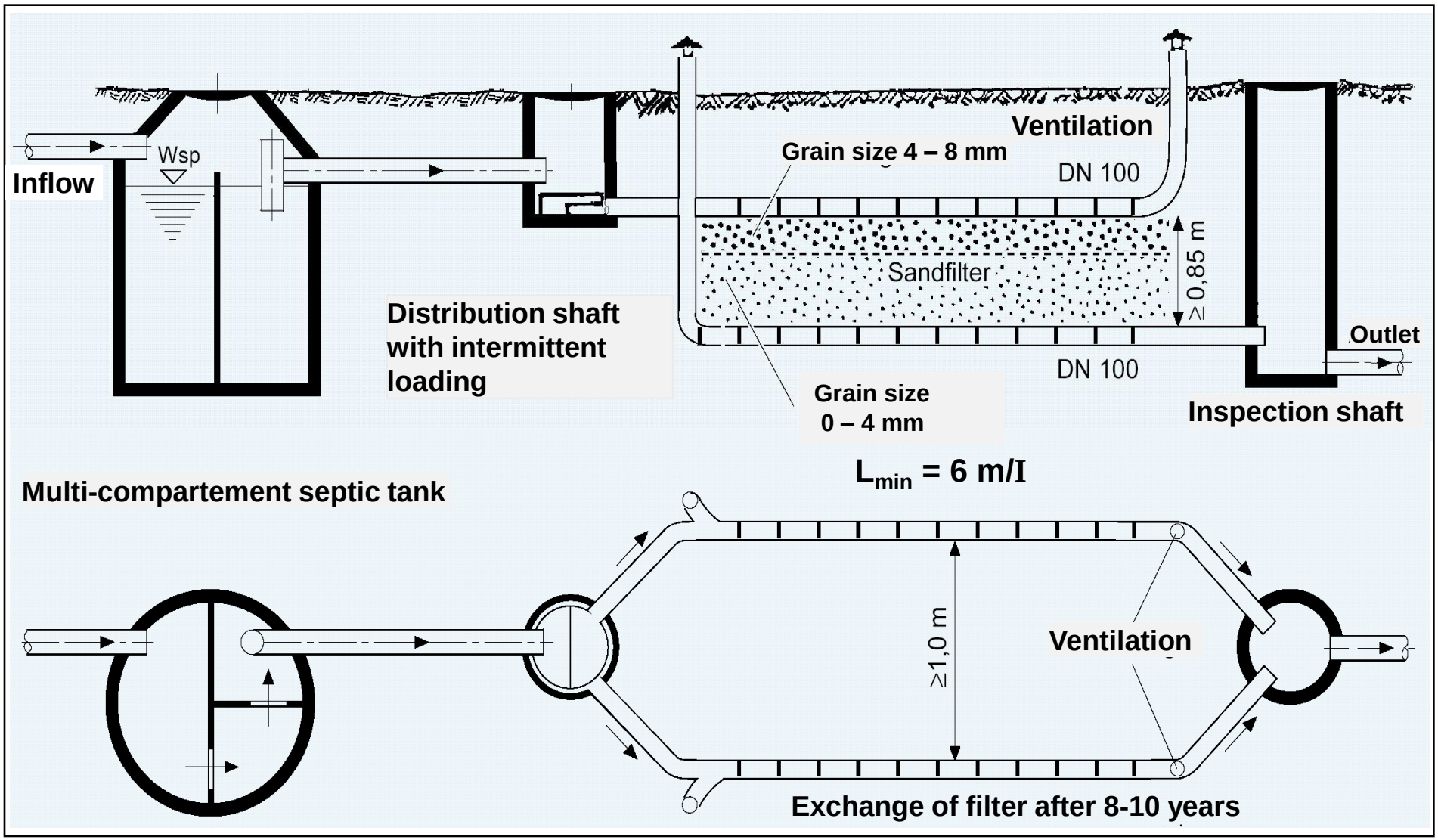


Outlet pre-treatment

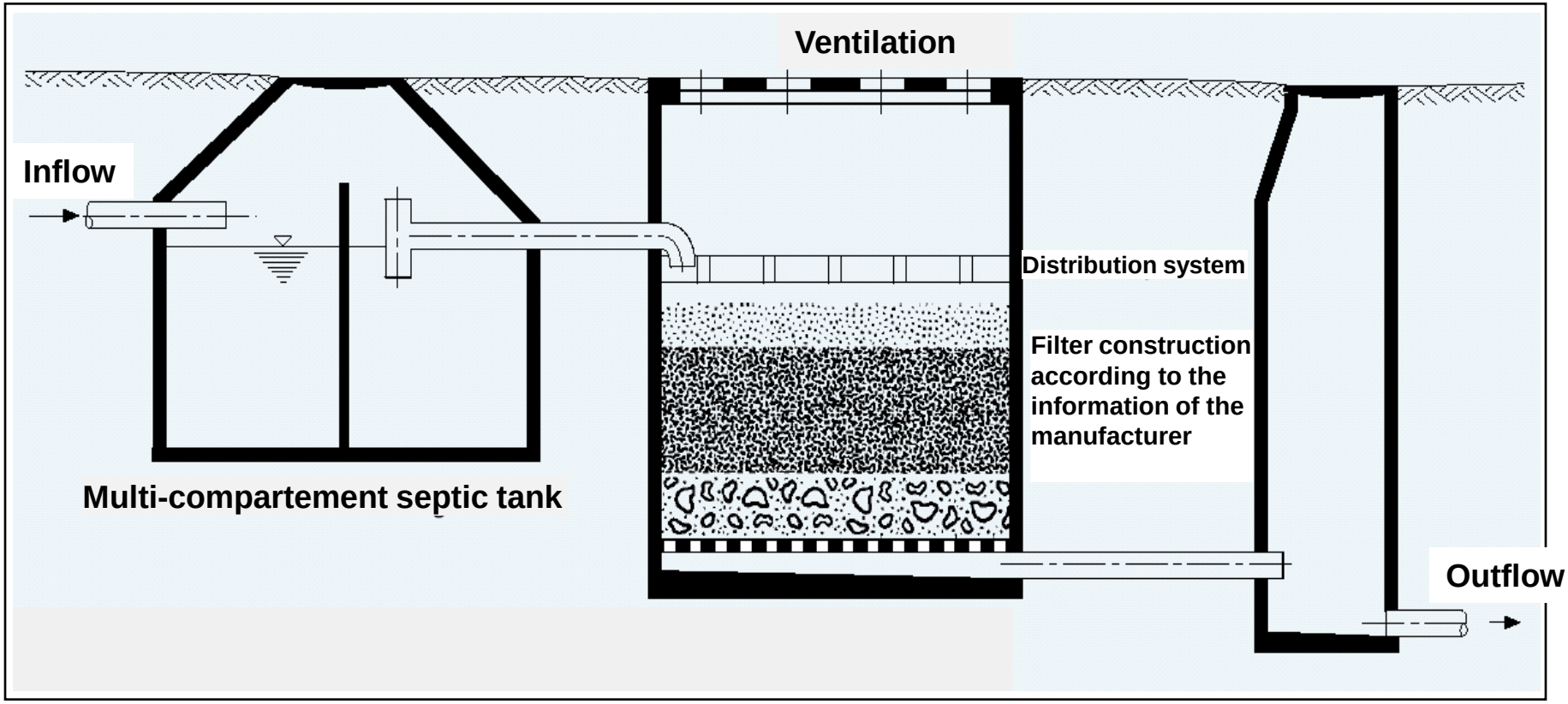
Cross beam or separate ventilation

No longer used for new plants!

Filter ditch

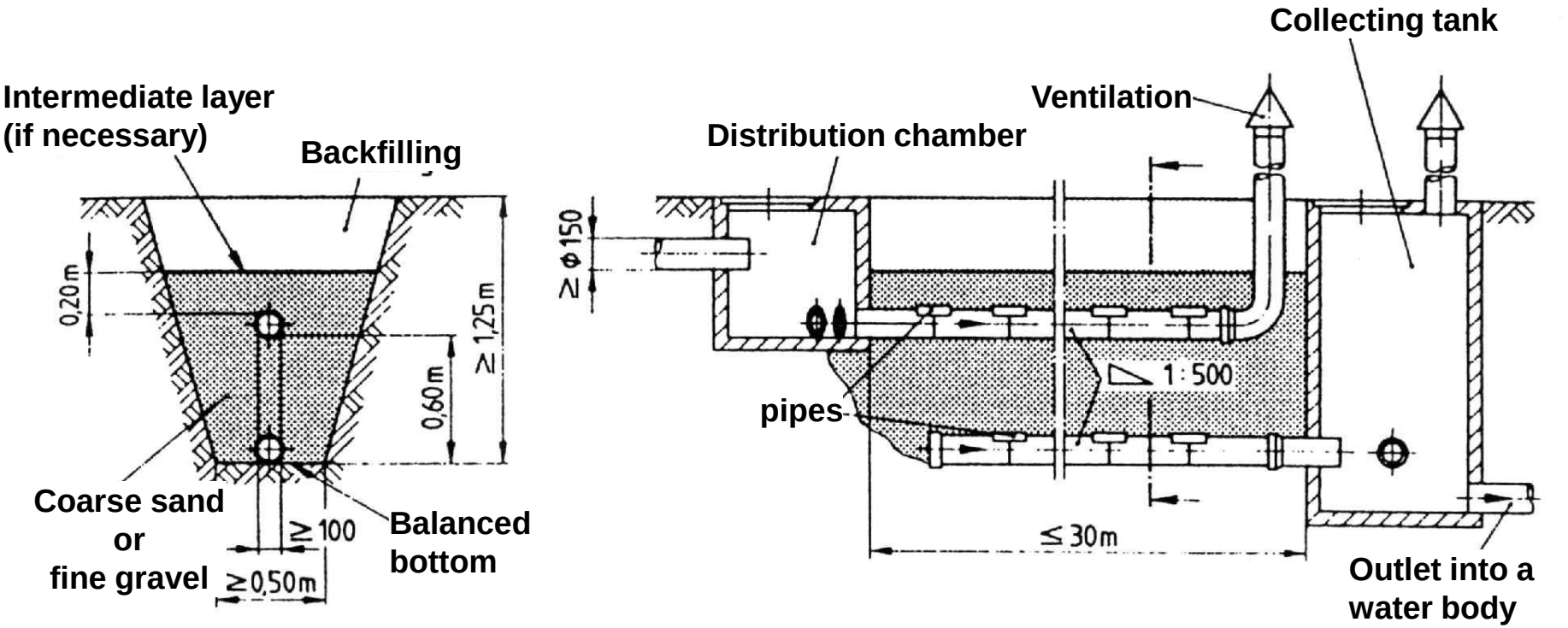


Filter shaft



Good ventilation + intermittent loading

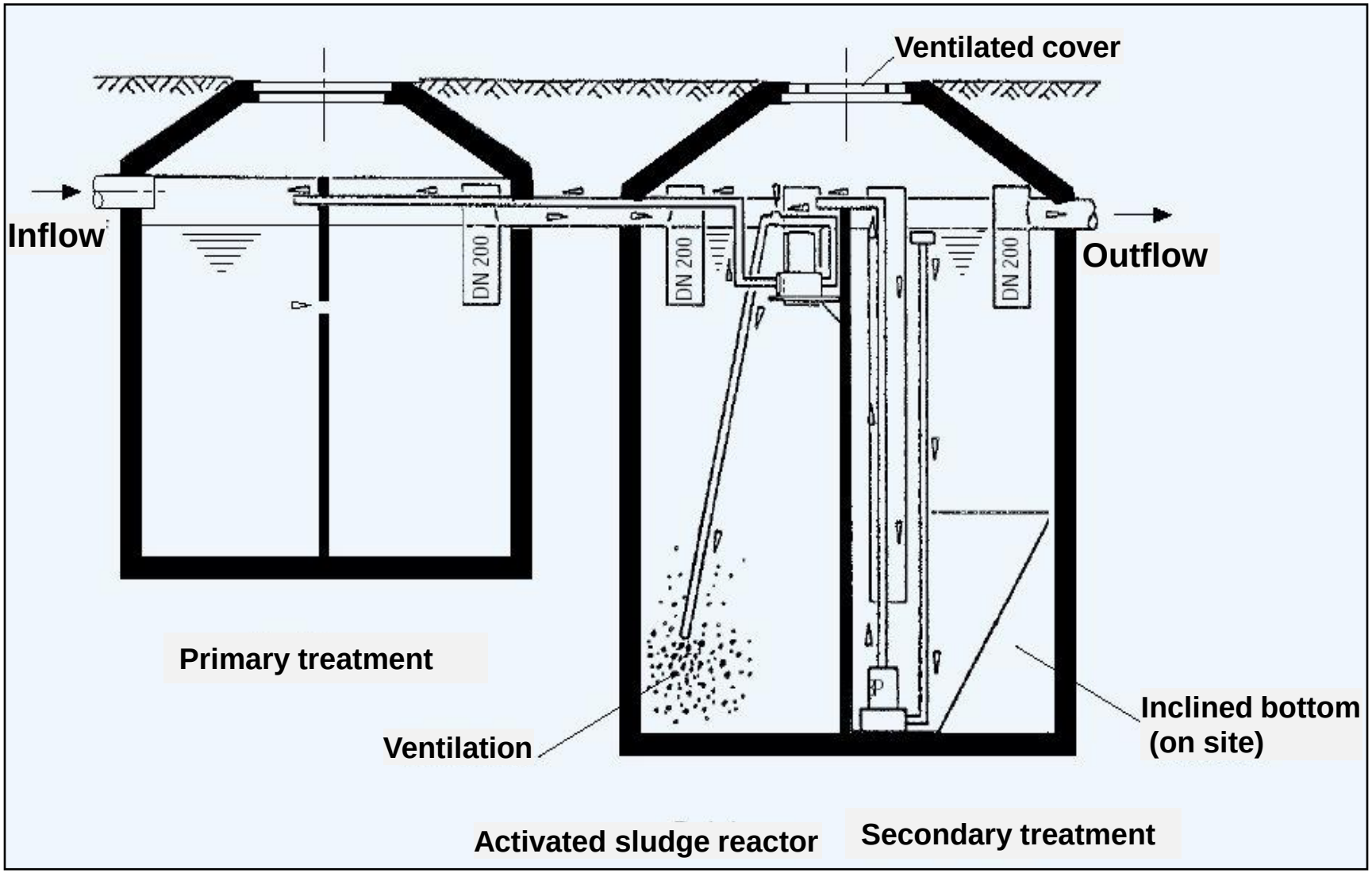
Filter ditch according to DIN 4261



Treatment processes in the water body

- Activated sludge process
- Trickling filter
- Submerged disk contact aerator *(Scheibentauchkörper)*
- Submerged packed bed *(getauchtes Festbett)*
- Wastewater lagoons/ponds

Small rural wastewater treatment plant: Activated sludge process



Small rural wastewater treatment plant: Activated sludge process

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Primary treatment

V_{PT} = 350 l/I

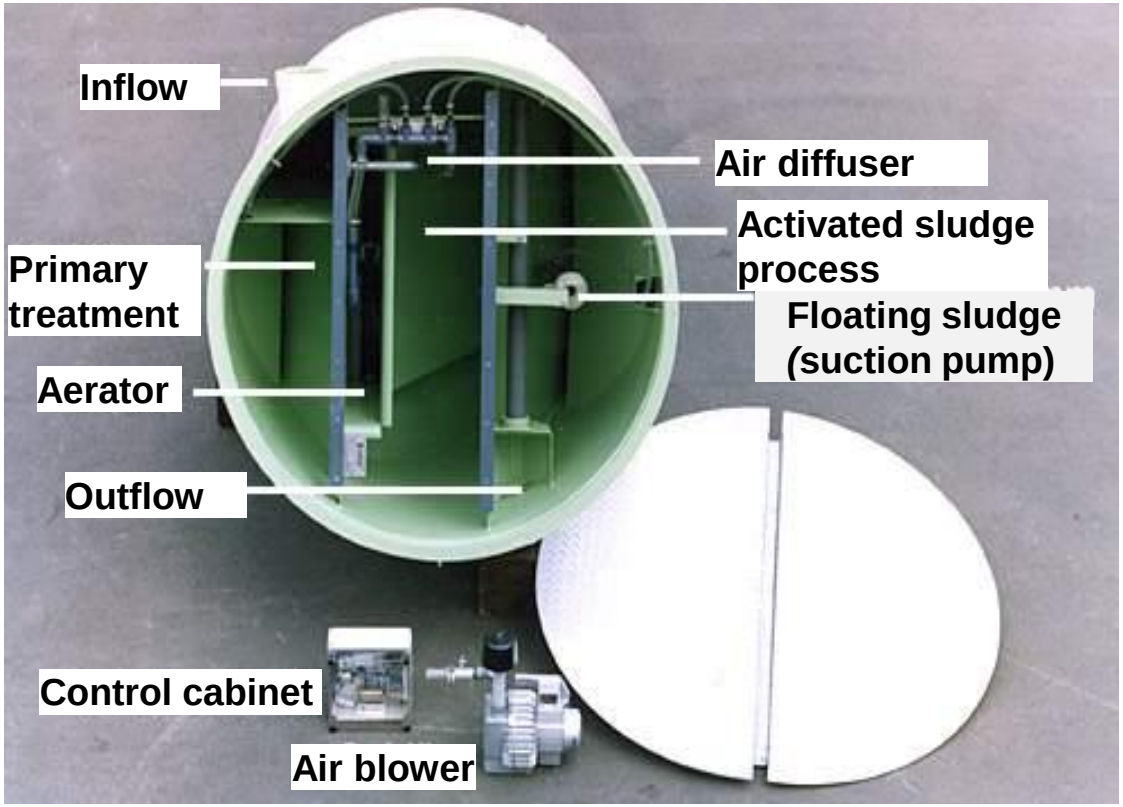
Activated sludge process

$B_{R,BOD}$ = 0.2 kg BOB_5/(m^3·d)

B_{SS} = 0.05 kg BOB_5/(kg SS·d)

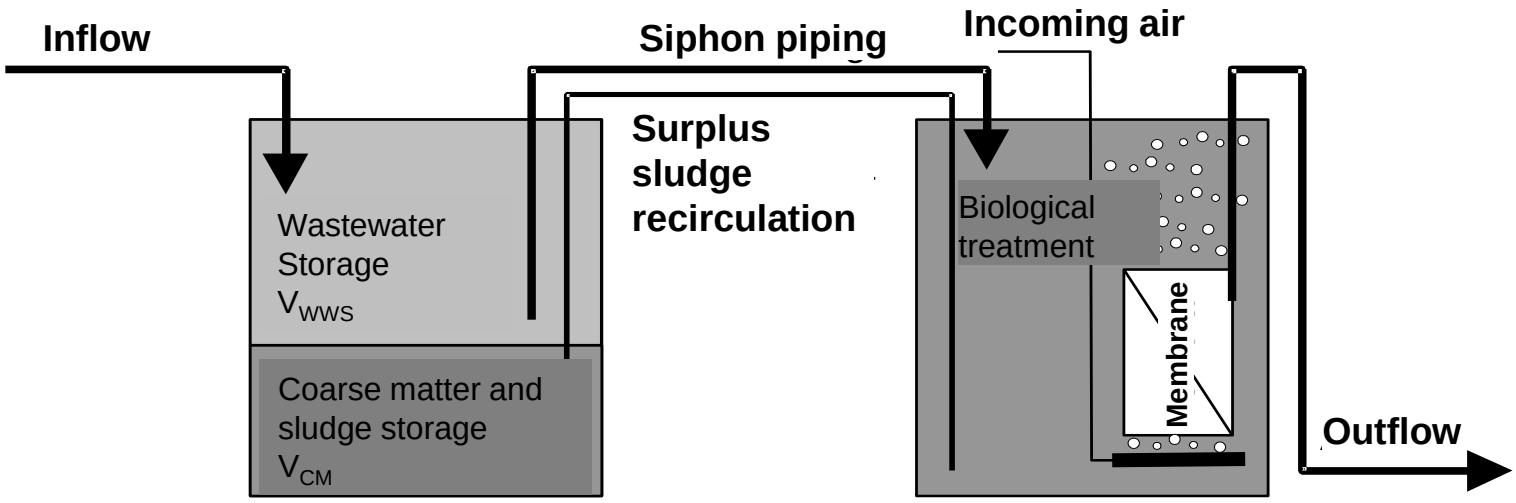
Secondary treatment

$q_A \leq 0.3$ m/h



Membran bioreactor

Example: Plant for 4 inhabitants



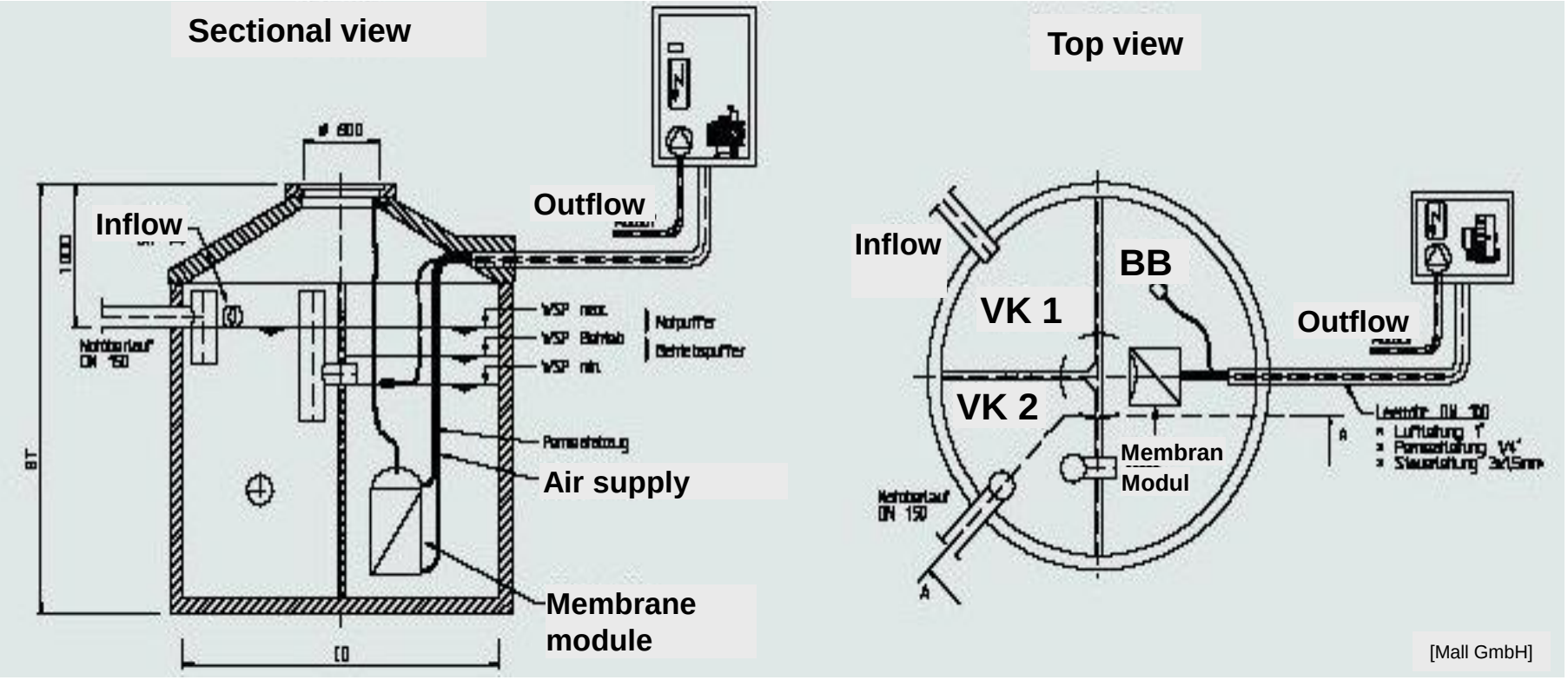
$V_{Biol.\ treatment}$ = 1.0 m³

$V_{CM/WWS}$ = 1.0 m³
V_{CM} = 0.4 m³
V_{WWS} = 0.6 m³

Membrane

A = 2,4 m²
Q = 20 l/(m²*h)

Membran bioreactor

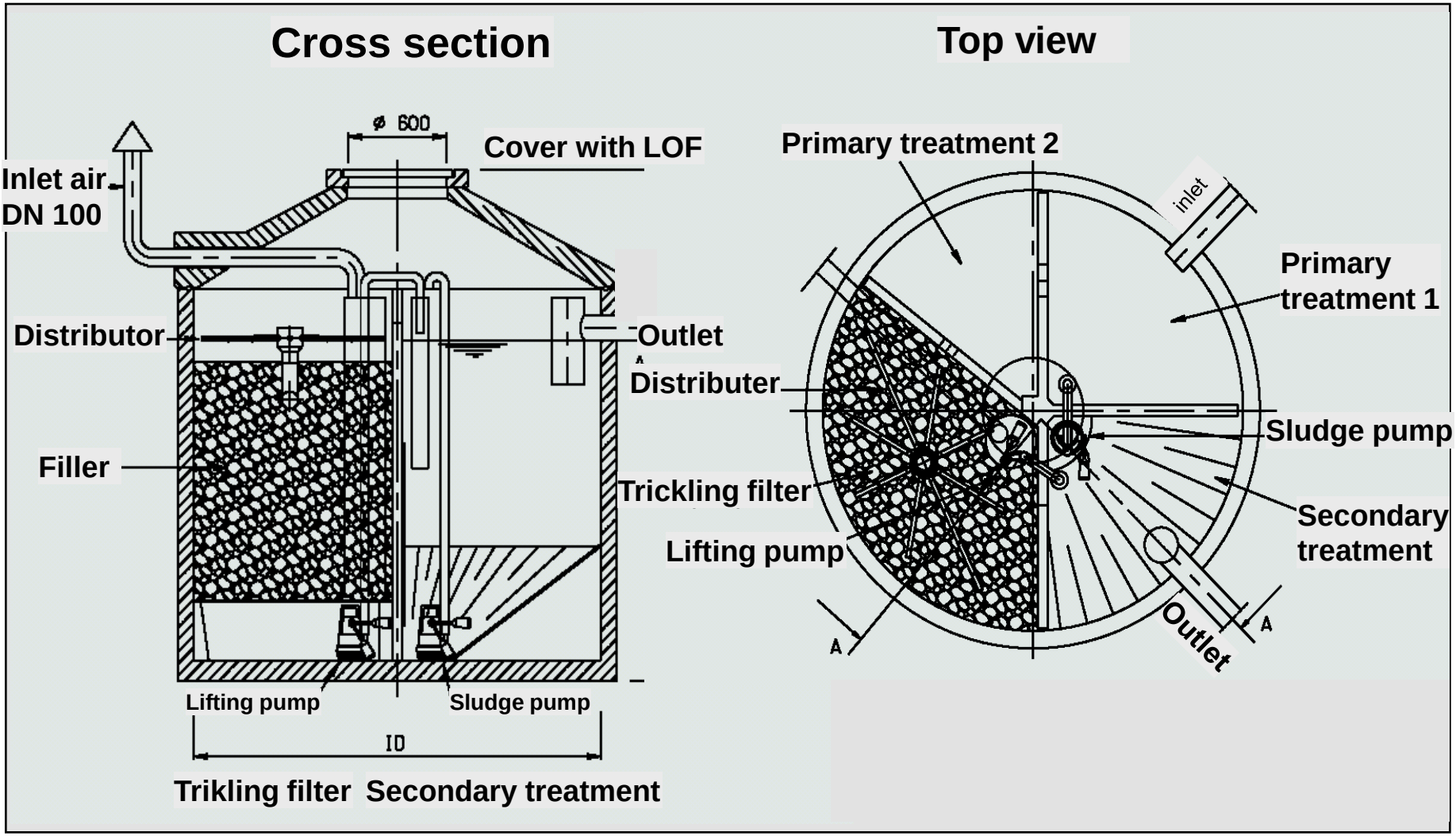


Membrane plants remain under the requirements of the EG-Bathing waters RL 76/160/EWG concerning the parameter of hygiene.

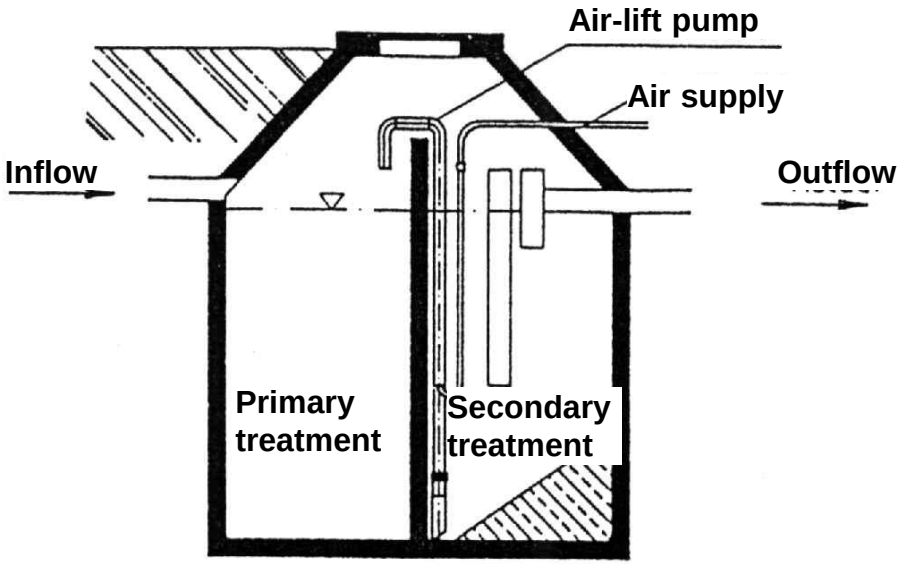
The COD- und BOD drainage concentration is more than 75% lower than the standards of the Wastewater Directive.

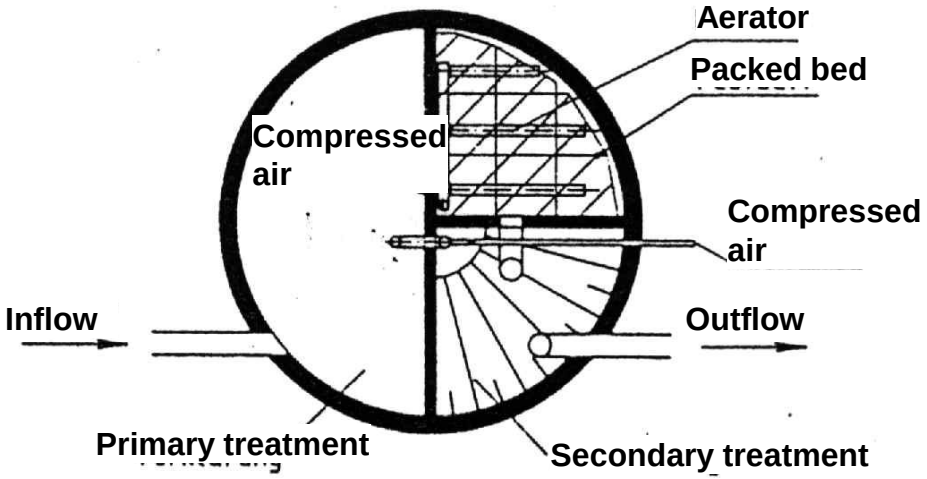
=> water reuse possible

Trickling filter method



Packed bed method: Example

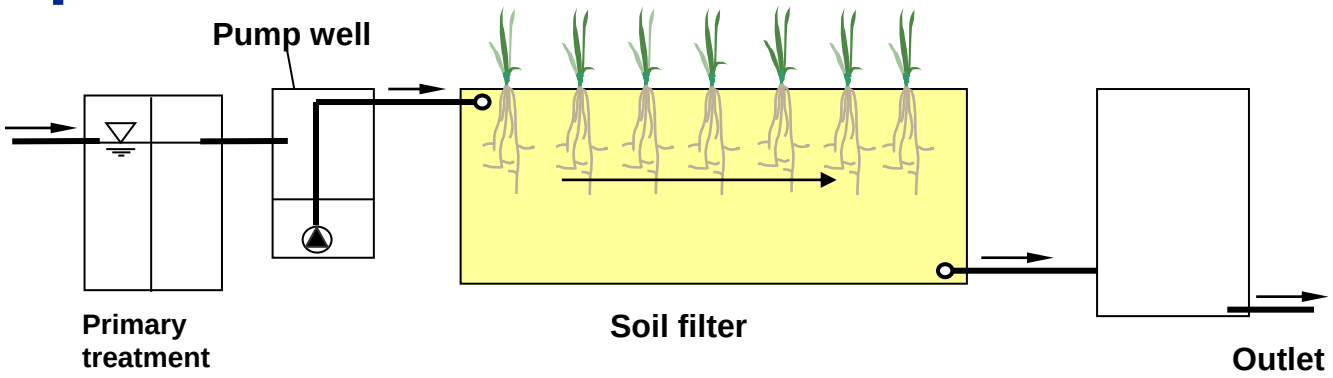




Constructed wetlands

- **Importance in the system**: either for biological wastewater treatment or simply for aftertreatment
- **pretreatment:** with or without pretreatment
- **Soil materials:** different substrate materials (gravel, sand, silt, clay), homogeneous or layered arranged
- **planting**: mono- or mixed cultivation (predominantly reed, in addition reed mace, iris, bulrush and club-rush).
- **Flow:** (vertically, horizontally or surfacely overflowed)
- **way of loading** (intermittent, continuous)

Constructed wetlands: Basic process variants

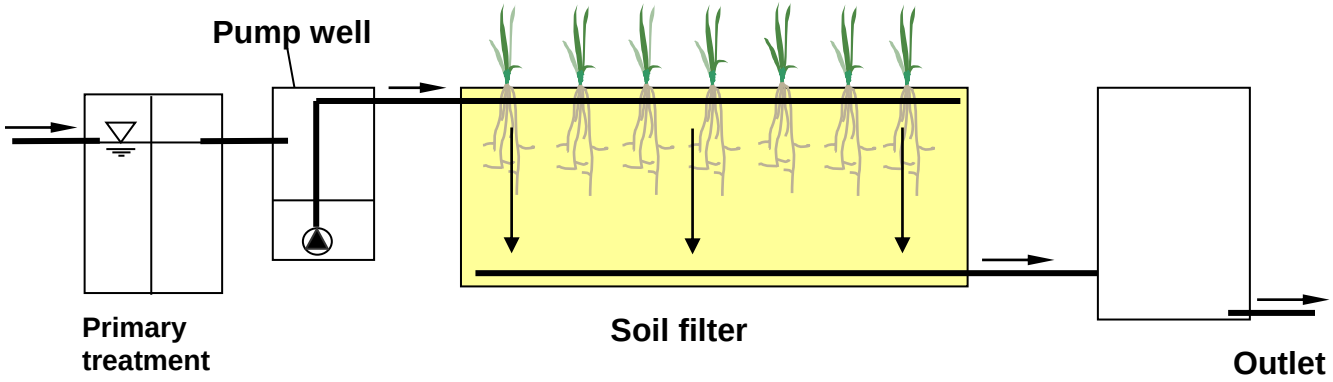


Horizontal-flow bed (horizontal filter)

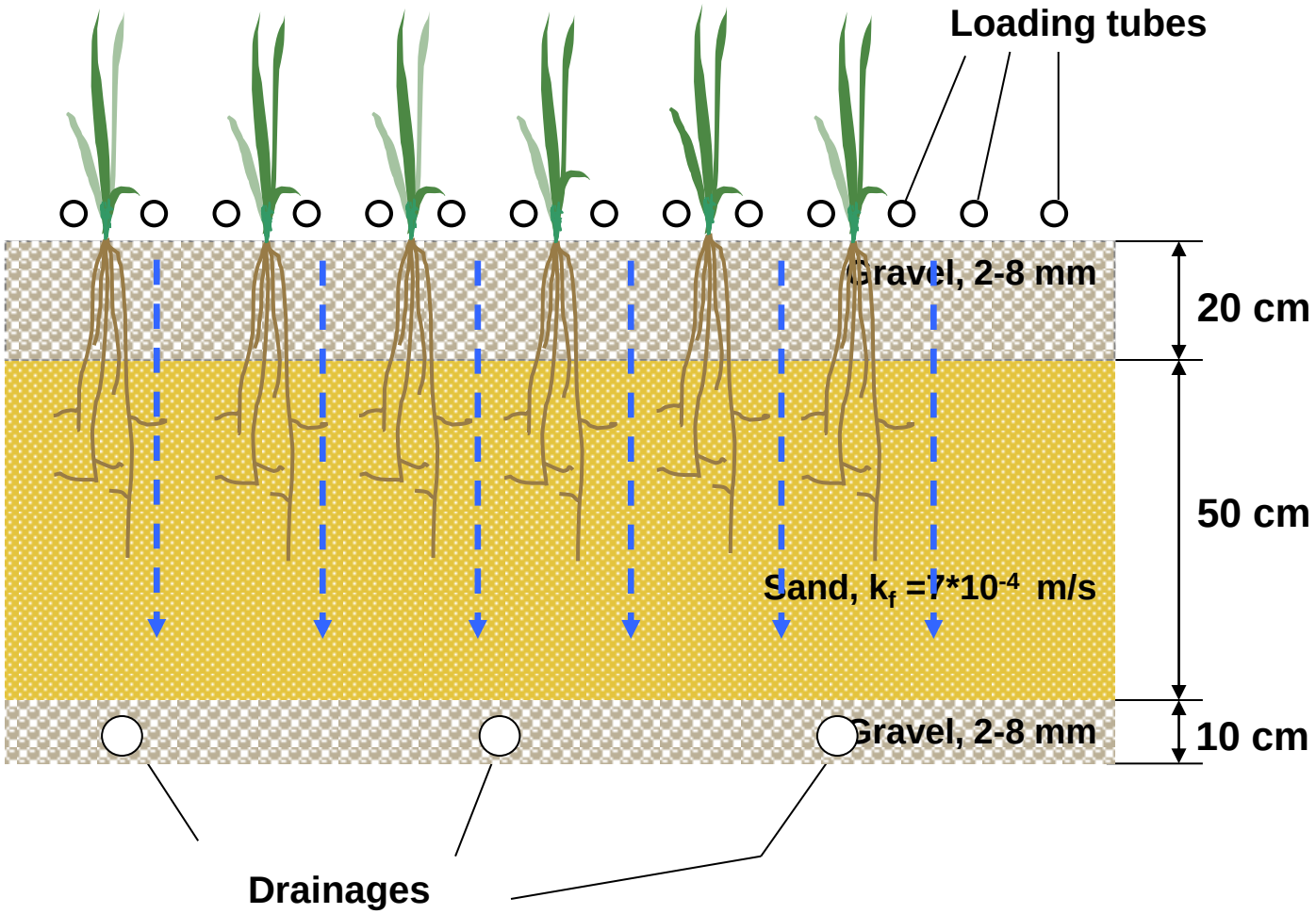
At the front side the water is led into a 0.6 – 0.8 m deep, reed planted bed and flows horizontally through it.

Vertical flow-bed (vertical filter)

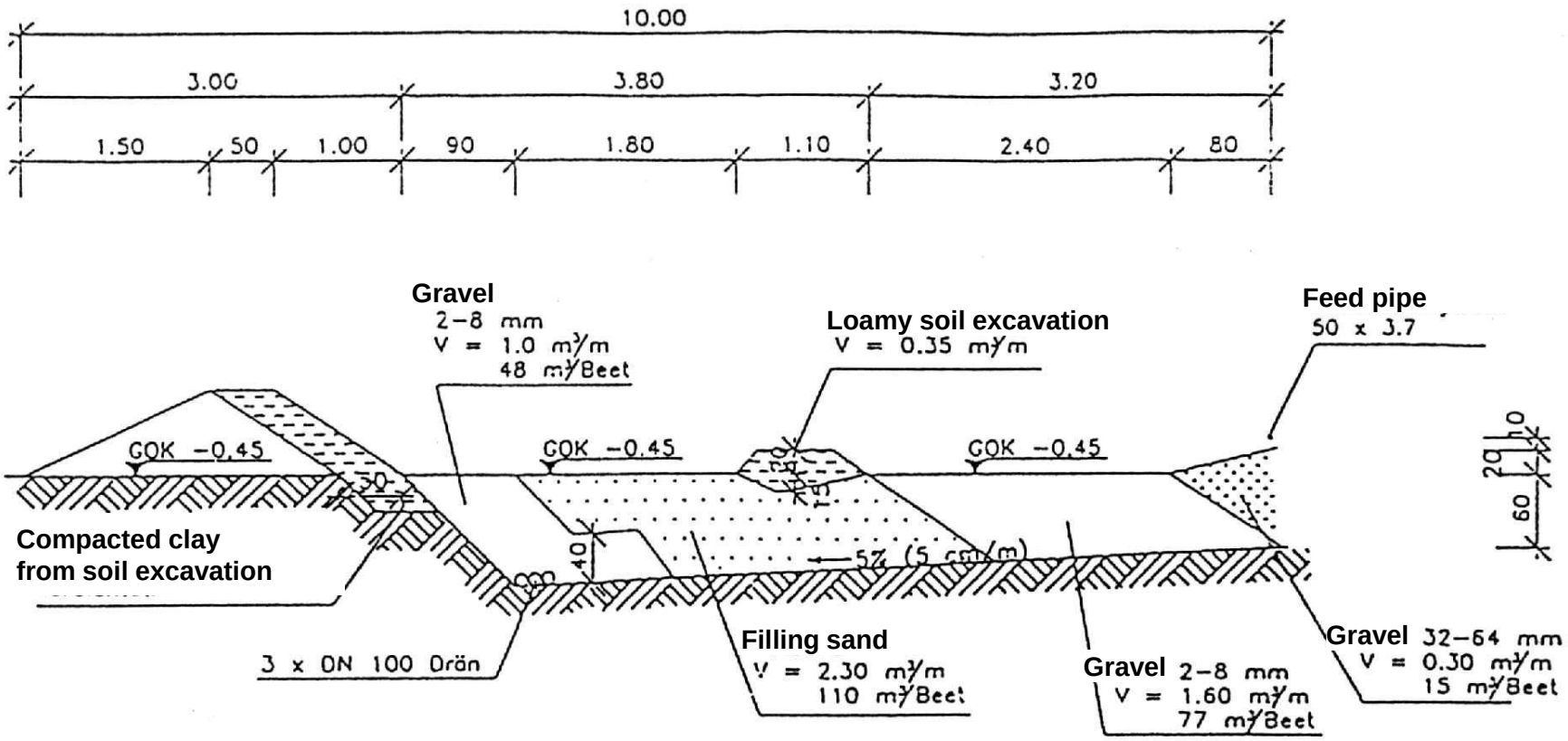
The water flows vertically through the bed material. It is brought up intermittently and collected by drainage pipes at the bottom of the bed.



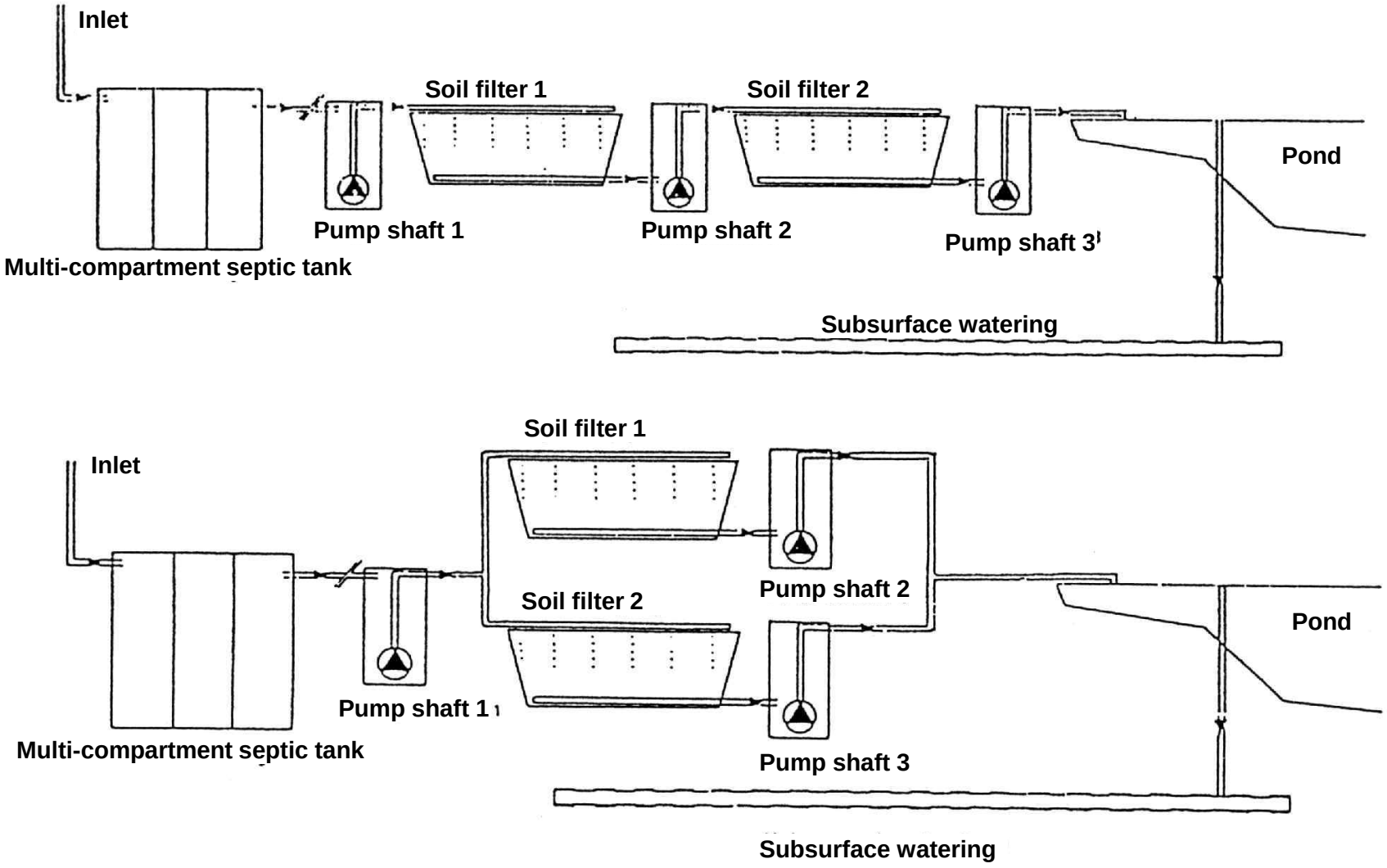
Typical construction of a vertical filter



Cross section of a horizontal filter bed



Construction of a vertical filter



Achievable discharge concentration of constructed wetlands

Method	Dimensioning factors	Discharge concentration [mg/l] BOD_5	COD	NH_4-N	P_{tot}
Vertical filter	3 m^3/I	**10**	**60**	**20**	**5**
1.0 m depth, batch-feed constructed	5 m^3/I	**5**	**40**	**10**	**2**
Horizontal filter	5 m^2/I	**40**	**150**	**5**	**5**
0.6 m depth, continuous feeding	10 m^2/I	**10**	**60**	**30**	**2**

Types of wastewater lagoons/ponds

ATV- A 201 (1989):

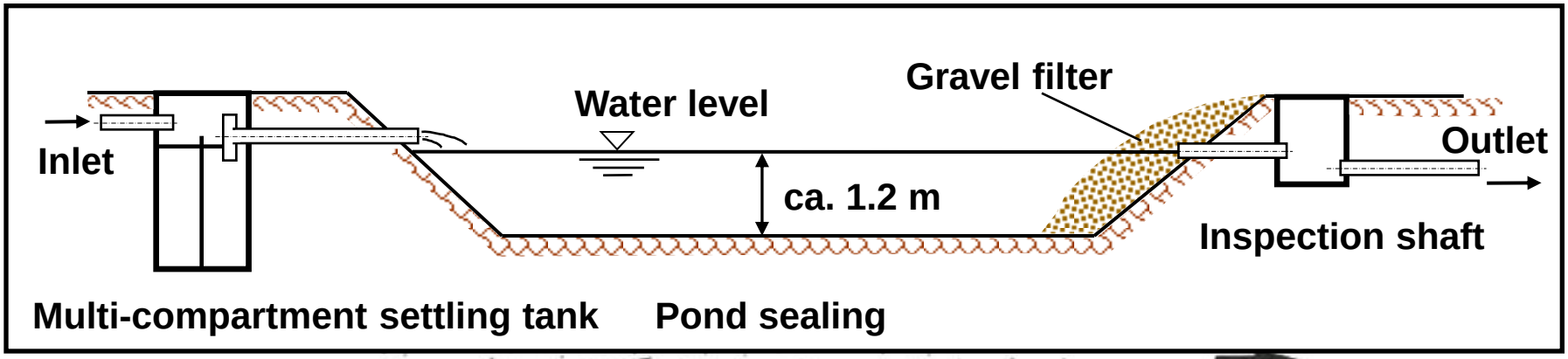
- **Settlement ponds:**
  Separation of the depositable substances contained in raw wastewater and for the digestion of the deposited sludge.

- **Non-aerated wastewater lagoons/ponds**

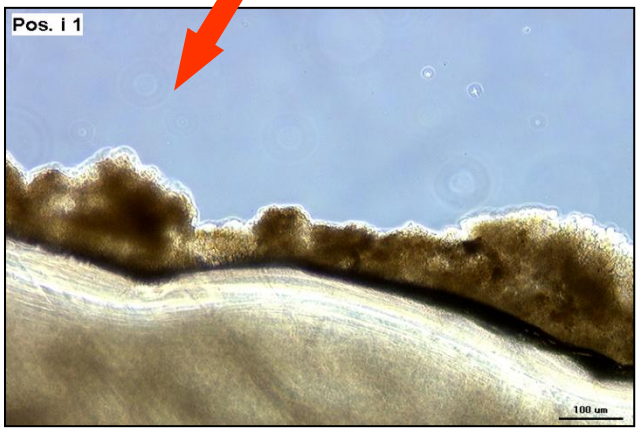
- **Aerated wastewater lagoons**
  Oxygen is introduced using mechanical aeration installations.

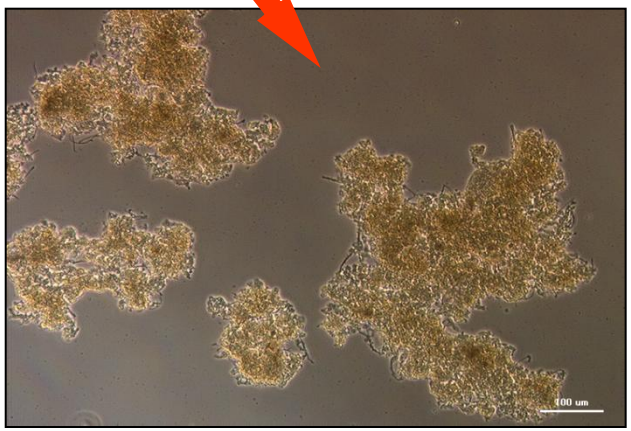
- **Polishing ponds**
  Wastewater lagoons used as tertiary treatment, typically for the removal of pathogenic microorganisms by exposure to solar radiation by competition and predation mechanisms.

Wastewater lagoons

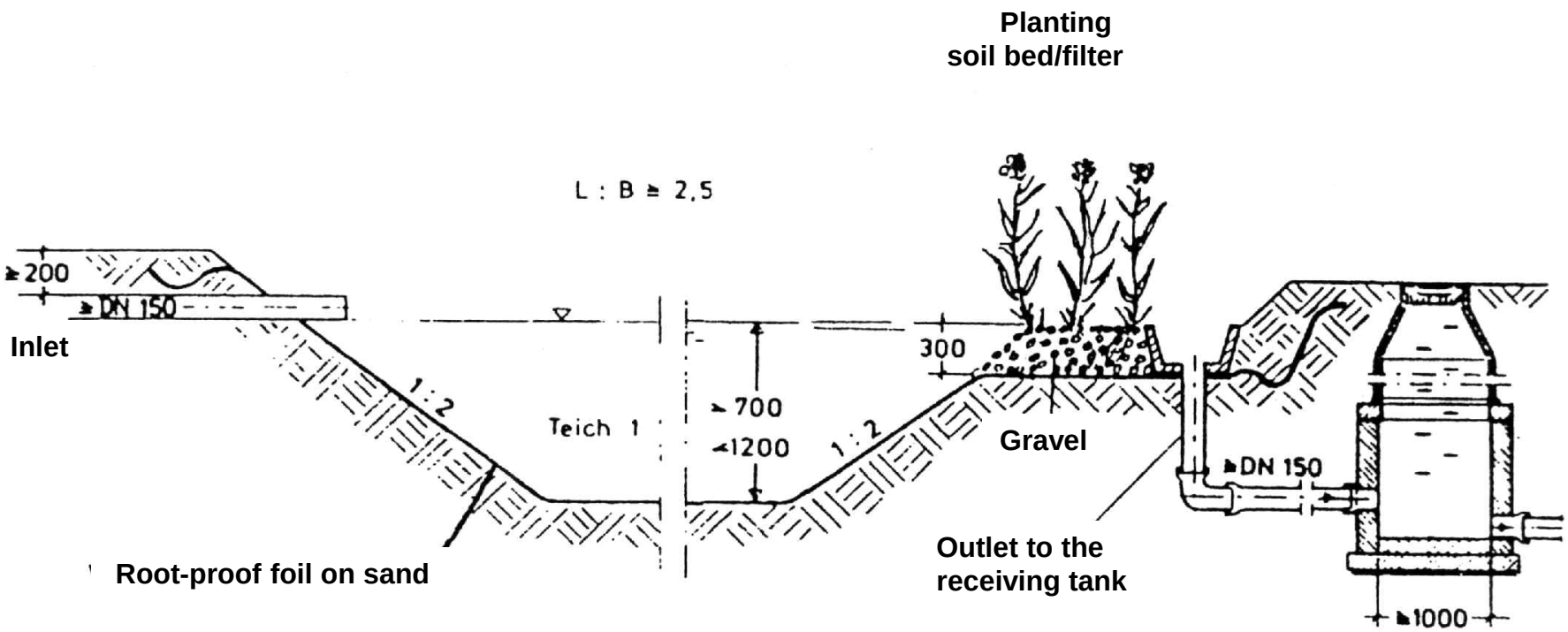


High buffer capacity
and working stability





Non-aerated wastewater pond



Floor Area and volume requirement, retention time and ability to nitrify of different methods in small wastewater treatment plants

Parameter	Area / I [m²]	Volume / I [m³]	Retention time	Nitrification
Subsurface watering	**4 - 20**	7 - 12	-	+
Plant bed, horizontal	7 - 12	3 - 6	4 - 10 d	±
Plant bed, vertical	≥ 4	≥ 4	7 d	+
Non-aerated WW pond	10	**10 - 15**	**> 20 d**	-
Aerated WW pond	3	4 - 7	< 3 - 6 d	±
Low load activated sludge process	0.12 – 0.25	0.3 -0.5	1 - 3 d	+
SBR	0.1 – 0.25	0.3 – 0.5	1 - 3 d	+
Trickling filter, nitrifying	0.17 – 0.3	0.25 – 0.35	6 - 10 min*	+
Trickling filter, not nitrifying	0.05 – 0.08	0.13 – 0.18	**3 - 6 min***	-
Packed bed, nitrifying	0.005 – 0.01	0.03 – 0.05	30 - 50 min	+
Packed bed, not nitrifying	**0.004 – 0.01**	**0.013 – 0.03**	20 - 40 min	

[BOLLER, 1995]

Advantages/disadvantages of wastewater ponds

Advantages:

- Cost-effective to design
- Use less energy than most wastewater treatment methods
- No or little mechanical effort
- Simple to operate and maintain and generally require only part-time staff
- Can handle intermittent use and shock loadings better than many systems (high buffer capacity)
- Possibility of construction that is adequate to nature

Disadvantages:

- Require more land than other treatment methods
- Odor can become a nuisance during algae blooms, spring thaw in cold climates, or with anaerobic lagoons and lagoons that are inadequately maintained
- Occasional heavy formation of algae
- Fluctuation concerning the cleaning capacity due to season and weather

Free-market potential

Small WWTPs in Lower Saxony:

plants for less than 50 inhab. with a feed < 8 m³/d

	Number of WWTPs
NDS	186,000
NRW	145,000
BRD	**ca. 5 % of the connected inhab.**

Price: ∅ **6,500 €**