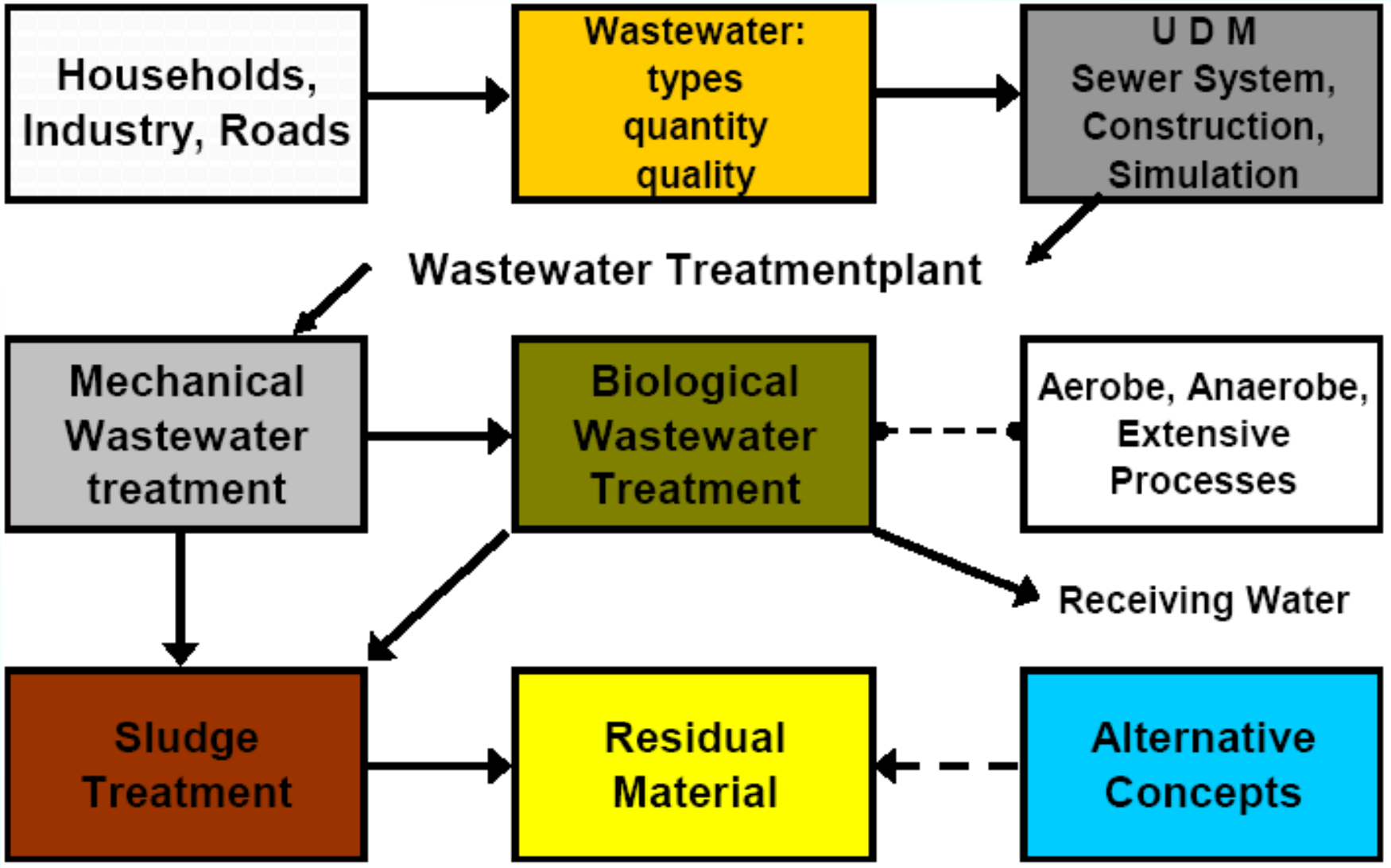
Content - Questions to be answered

Waste- (water) Treatment

- What is it? From Where & How Much? (quantity & quality)
- Why must wastewater be treated? (Environmental Protection & Legal Framework)
- How to collect wastewater? (drainage system & other concepts)
- How does a treatment plant work? (conventional, large treatment plants)
- Any other possibilities of wastewater treatment?
- What to do with the sludge? (sludge treatment & disposal)
- Are these sanitation concepts available & appropriate for all over the world? (alternative concepts)
- How to monitor and evaluate the quality of surface waters? (saprobic system)

Overview & Scheme



From Where? → Wastewater types

Wastewater consists of:

- Wastewater
  - **Domestic ww**
  - **Industrial ww**
- **sewer infiltration water** (extraneous water)
- **Stormwater**

Wastewater types - Domestic ww

Estimation of yield:

- Catchment area
- Population density
- Specific water consumption

Domestic wastewater originates from:

washing, showering, bathing, cooking, cleaning, toilet flushing…

Table 1 Domestic wastewater (1 PE)

	Polluting load			Concentration		
	total	organic	inorganic (mineral)	total	organic	inorganic (mineral)
	[g/P.d]	[g/P.d]	[g/P.d]	[mg/l]	[mg/l]	[mg/l]
Total Waste Substances	190	110	80	1260	730	530
dissolved Substances	100	50	50	660	330	330
undissolved Substances	90	60	30	600	400	200
…thereof settleable	60	40	20	400	270	130
…thereof non settleable	30	20	10	200	130	70

Wastewater types - Domestic ww - quality

Table 2

Load and Concentration of **one PE**

expressed in wastewater related parameters (PE60)

Parameter	**Load** [g/P.d]	**Concentration** [mg/l]
COD (Chemical Oxygen Demand)	120	600
BOD_5 (Biological Oxygen Demand within 5 days)	60	300
Total Nitrogen	11	55
Total - Phosphorus	2	10
SS (Suspended Solids)	60 - 80	300 - 400

Wastewater types - Domestic ww - quantity

variations in
quantity and **quality**
during one day and
during working days and weekend.

- **Urban areas** have lower discharge rates during the weekends.
- **Tourist regions** can have very high discharge rates during the weekends.
- **During the nighttimes** low discharge rates (according to common lifestyle)
- **Smaller sewer systems** show higher variations

Wastewater types - Domestic ww - quantity

Table 4

Domestic wastewater discharge

Hydraulic load per PE

Occurrence	Range [%]	Mean [%]	Mean [l/d]
Kitchen	9-15	12	20
Bath / Shower	25-40	32	55
Hand washing	3-13	7	12
Toilet	22-40	30	51
Washing (laundry)	12-25	16	27
Carwash	2-3	3	5
Total	-	100	170

Wastewater types - Domestic ww - quantity

Table 5 Domestic wastewater discharge according to population number

Population number [P]	Daily wastewater discharge [l/(P.d)]	Hourly peak discharge coefficient 1/x	Specific hourly peak discharge coefficient [l/s.1000 P]
< 5.000	150	1/8	
5.000 - 10.000	175 - 180	1/10	
10.000 - 50.000	200 - 220	1/12	App. 5,0
50.000 - 250.000	225 -260	1/14	
> 250.000	250 - 300	1/16	

Wastewater types - Domestic ww - quantity

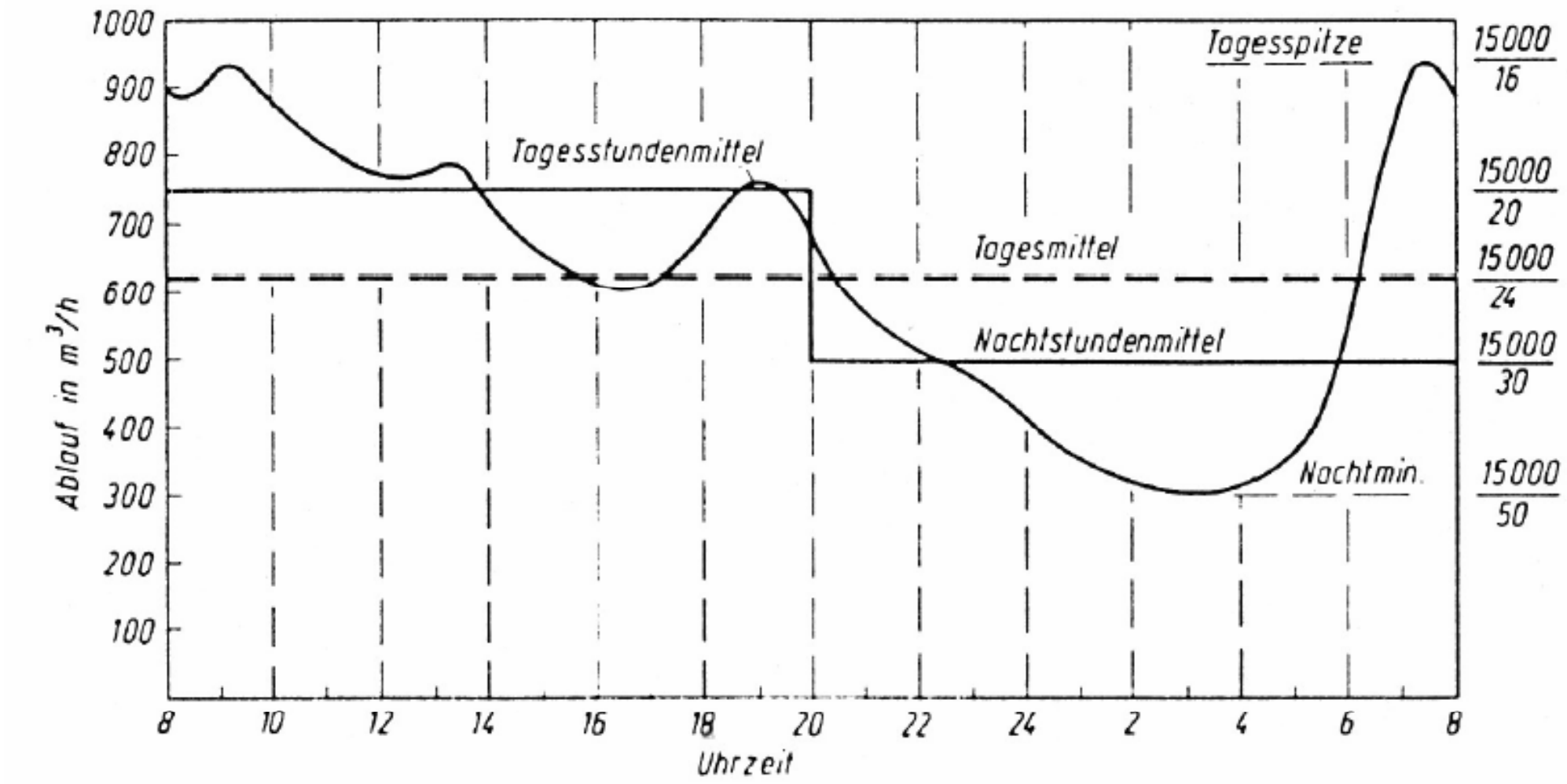


Figure 1 Course of a day – dry weather flow of a city with 85000 Inhabitants, incl. industry

Wastewater types - Industrial ww – quality

Mainly influenced by the manufacturing processes:

- Cleaning processes
- Discharge of cooling water

The wastewater, it can be aggressive to sewer material:

- Concrete (acids, low pH)
- Temperature (hot wastewater > 35 °C) can affect old (bitumen based) sealings.

Depending on quality (and quantity) industrial ww can be:

- **Directly discharged** (into receiving water, treatment if needed)

or

- **Indirectly discharged** (into sewer system → WWTP, pre-treatment if needed)

Wastewater types - Industrial ww - quantity

Industrial discharge is varying dependent on the different processes:

- **Estimation** for every different case.
- Working hours only during the day will increase the **peak flow**
- 24 hour production smoothens the peak flow.

Wastewater types - Extraneous water – quality 21.11.

… **should actually not be discharged into the sewer.**

- **It can originate from Groundwater**
- **Spring water**
- **Water from drainage systems etc.**

Once collected, extraneous water is also led to the treatment plant

- Causes **higher running costs** for treatment (energy),

- **higher investment costs** for a larger design of the utility (hydraulic load)

and / or

- **less treatment performance**

Wastewater types - Extraneous water - quantity

Estimation (3 different ways):

- **3 l / s*1000 PE**
  (according to ÖWAV directive 11 (1982))

- Twice the amount of domestic + industrial wastewater (**100 % additional**)
  (used for the simulation of the sewer system according to ATV (1994))

- **0.05 to 0.15 l / s*hectare** – according to the region
  (planning of new sewer system)

Wastewater types - Stormwater- quality

originates from

- Streets and squares
- Roofs

According to the ATV guideline A 138 (1990) (now called DWA) a division can be made between polluted and unpolluted stormwater.

- **Unpolluted stormwater can be infiltrated locally**

Wastewater types - Stormwater- quality

Table 3 **Concentrations of Stormwater**

Parameter	Unit	Rainfall	Roof run-off	Street run-off
pH	-	4,9	6,2	6,4
Electrical conduct.	µS/cm	32	80	108
SS	mg/l	n.d.	60	564
COD		5	22	49
DOC		1,5	18	12
NH_4-N		0,2	4	0,2
NO_3-N		0,6	0,2	0,6
NO_2-N		0,05	0,3	0,02
PO_4-P tot		0,2	0,3	1,5
Lead	µg/l	5	104	311
Cadmium		1,5	1	6,4
Zink		5	24	603
Copper		1,5	235	108
Nickel		5	-	57

Wastewater types - Stormwater- quantity

Run-off discharge rate:

If there is no regional data available, it can be estimated with:

- $r_{15,n=1}$ = **120 l/s*hectare** (flat area)
- $r_{15,n=1}$ = **150 l/s* hectare** (alpine area)

Rainfall with duration T=15 min, annuality = 1

run-off factor ψ: actual discharged into the sewer system

… depending on:

- Character of the surface
- Rate of paved area (buildings, roads and pavement)
- Inclination of the ground

Substances in the Wastewater

Estimation of Wastewater Quality

Depending on mixture of:

- **wastewater** (domestic / industrial:
  mainly organic pollutants, pathogens (pathogenic bacteria and viruses, parasites)
  or substances according to industry)

- **stormwater** (mainly inorganic components)

- **extraneous** water (dependent on its origin)

General physical properties of Wastewater

Temperature

- Domestic wastewater: Depending on the season from **10 to 20 °C**
- Groundwater: **6 to 12 °** (also depending on the season)
- Water with more than 35 °C must not be discharged into the sewer system (old bituminous sealings)

Odour

- Fresh domestic wastewater: musty-smell.
- organic matter with low oxygen concentrations: **digestion processes**
- → result in bad smell because of the formation of **hydrogen sulphide (H_2S).**

Colour and turbidity

- Fresh wastewater: brown-grey to light-grey
- **Digested wastewater**: black-grey colour
- Heavy rainfalls will remove sedimentations → turbidity will increase

General physical properties of Wastewater

Coarse matter

- Large coarse matter (wood, tins, dead rats etc.)
- Fine coarse matter (faeces, paper, sanitary towel, condoms, etc.)
- **Removal by a screen** (screenings are dewatered and disposed of)

Settleable matter

- Common property: Higher spec. density than water
- E.g. mineral substances (sand), parts of food or faeces
- **Removal: grid chamber** and the **primary clarifier**

Floatable matter

- Common property: Lower density than water
- E.g. oil or grease
- Removal: aerated grid chamber and the primary clarifier
- **Removal at "top of pipe" is easier** and more efficient

General physical properties of Wastewater

Non-settleable matter

- Very fine particles will not settle and stay suspended (= turbidity)
- **Removal: biological treatment + secondary clarifier**; sometimes by adding of chemical agents.

Dissolved substances

- Dissolved organic carbon (DOC)
- Nutrients (N, P)
- **Removal: biological treatment**

General chemical properties of Wastewater

Organic carbon (major substance in wastewater)

Organic matter from man, animals or plants

- Common property: Organic pollutants contain carbon and are flammable

Organic carbon affect the water-ecosystem:

- because of **oxygen depletion** (microbiological consumption of oxygen) during degradation of carbon by MO **(link: Why must wastewater be treated)**

Removal: organic matter is degraded by MO's metabolism during the **biological treatment** (consumed → removed)

Parameters for total organic contents are

COD, BOD_5, TOC and DOC.

General chemical properties of Wastewater

Nitrogen (major nutrient)

- Mainly found in protein, biomass contains about **4 to 7 % nitrogen**
- Usually nitrogen is **not the limiting factor** for primary biomass growth

nitrogen can affect the water-ecosystem in many ways:

- **Ammonium** (NH_4^+) because of its oxygen depletion (microbial consumption of oxygen)
- Ammonia (NH_3) and nitrite (NO_2^-) are **fish toxins** **(link: Why treat wastewater?)**
- Nitrate (NO_3^-) is a handicap for the utilisation for drinking water purposes

Nitrogen is consumed / removed or transformed by MO during the **biological treatment**.

Nitrogen parameters are:

N_{tot}, NH_4-N, NO_3-N, NO_2-N, N_{org} and **TKN** (= NH_4-N + N_{org})

General chemical properties of Wastewater

Phosphorus (major nutrient)

- Biomass contains about **1 % phosphorus**
- Usually phosphorus **is the limiting factor for primary biomass production in waters**

An increasing phosphorus concentration will cause

- **eutrophication**.

= increasing primary biomass production. **(link: Why must wastewater be treated)**

- Phosphorus is removed by MO's during the **biological treatment**.
- Phosphorus can be removed chemically (precipitation)
- Phosphorus parameters are: PO_4-P and P_{tot}.

General chemical properties of Wastewater

Inorganic matter

- Common property: No carbon contained
- = Mineral substances
- Sand etc., Dissolved salts

Toxic substances

- Toxic substances can affect the performance of microbiological treatment.
- Microbiological degradation can be hold back or even stopped
- Toxic substances should be kept away from wastewater.

General microbiological properties of Wastewater

Pathogens

- Viruses, Bacteria, Worm eggs
- Pathogens are largely removed during the **biological treatment**.

Complete removal or disabling of pathogens **can only be achieved with disinfection**.

Environmental Protection & Legal Framework

Self cleaning effects of rivers:

- Self cleaning processes are **natural effects**
- MO in the water **degrade organic carbon and nutrients** (metabolism)
- Oxygen (limited amount!) is provided by gas exchange on the surface

- **Pollution** (untreated wastewater or poorly treated effluent of WWTP) transfers the processes of degradation into the river

- **oxygen depletion** (microbial consumption of oxygen) or pH-shift can result in toxic degradation products like nitrite ($NO_2^{-)}$ or Ammonia (NH_3)

- Clean (unstressed) waters have a very low self cleaning capacity (low MO density)

Environmental Protection & Legal Framework

"combined approach“: **Emission** (concentration of the effluent)
& Immission (concentration in the environment)

- The emission principle defines **a minimum standard** for waste water treatment (effluent concentration)
- The concentration principle defines **quality standards for waters**; important for protection (concentration after mixture)

EU regulation on treatment of municipal waste water (91/271/EEC) was translated into national law by the following regulations:

- **general regulation of wastewater emissions** into waters and public sewers (AAEV 1996)
- limitation of **emissions from wastewater** treatment plants (1stAEVkA 1996)
- limitation of **emissions from single object treatment plants**

Environmental Protection & Legal Framework

AAEV (general regulation on wastewater emissions) is about:

- **collection** of wastewater,
- **treatment** and
- discharge into waters or public sewers

1st AEVkA (regulation on wastewater emissions coming from wastewater treatment plants):

- **discharge of domestic-ww-TP effluent** into flowing waters
- additional regulation on **nitrogen and phosphorus** elimination depending on the plant size
- Valid for any plants with a daily load of **50 PE_{60}** or more

Environmental Protection & Legal Framework

Waste water disposal in the rural areas

- For plants with less than **50 PE**:
- A **type-standardisation** for small sewage treatment plants (less than 50 PE) has to replace the missing 2nd AEVkA.

- **Single objects** in special situations are regulated in the **3rd AEVkA.**

Environmental Protection & Legal Framework

Table 2 Draft of the immission regulation (for waters with $Q_{95\%}$ > 400 l/s and catchment area > 50 km^2)

Parameter	Chemical bond	Immission limit values	
		Rhitral waters	Potamal waters
Oxygen content	O_2	> 7,5 mg/l	6,5 mg/l
Ammonium	NH_4+-N	0,3 mg/l	0,5 mg/l
Ammonia	NH_3-N	0,02 mg/l	0,02 mg/l
Nitrate	NO_3-N	6,0 mg/l	6,0 mg/l
Nitrite	NO_2-N	0,02 mg/l	0,05 mg/l
Phosphorus (solved)	P	0,07 mg/l	0,15 mg/l
Biochemical Oxygen Demand	BOD_5	3,5 mg/l	6,0 mg/l
Dissolved Organic Carbon	DOC	3,0 mg/l	5,5 mg/l
Biological water quality		II	II

Environmental Protection & Legal Framework

Table 3 Comparison of the limit values and demanded cleaning achievements.

Parameter	1st AEVkA (regulation on emissions from WWTP)				91/271/EEC (treatment of municipal waste water)	
	50-500	500-5.000	5.000-50.000	>50.000	all areas *)	sensitive areas
BOD_5 (mg/l)	25	20	20	15	25	25
COD (mg/l)	90	75	75	75	125	125
NH_4-N (mg/l)	10	5	5	5	-	-
N_{tot}	-	-	70 % (>12°C)	70 % (>12°C)	-	15 mg/l 1) 10 mg/l 2) 70-80% 3)
P_{tot} (mg/l)	-	2 (>1.000 P.E.)	1	1	-	2 1) 1 2)