Lecture 12

Wastewater composition, Analysis and Requirements

Part: Composition

Constituents of wastewater and its effects

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Impurities *(Störstoffe)*

have no direct impact on the mechanical and biological process of waste water purification and the aquatic environment, but they have a negative effect on the operation of the sewage plant.

Degradable organic substances *(Abbaubare organische Stoffe)*

are catabolised by bacteria under consumption of oxygen (O_2-consumption). They have to be eliminated in order to prevent disturbances in the oxygen balance of the aquatic environments.

Definition: BOD = Biological (Biochemical) Oxygen Demand

COD = Chemical Oxygen Demand

Constituents of wastewater and its effects

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Nutrients (N, P) *(Nährsalze)*

support the growth of biomass and therefore cause eutrophication of stagnant or slowly flowing water (i.e. secondary pollution due to the intense oxygen consumption when the biomass dies).

Hazardous substances *(Gefährliche Stoffe)*

or that are harmful to health, operate inhibiting or toxically on the sewage‘s micro organisms and the living organisms in the successive aquatic environment.

Inhabitant-specific loads in g/(I·d)

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Inhabitant-specific loads in g/(I·d), which are undercut on 85% of the days, without taking into account sludge liquor

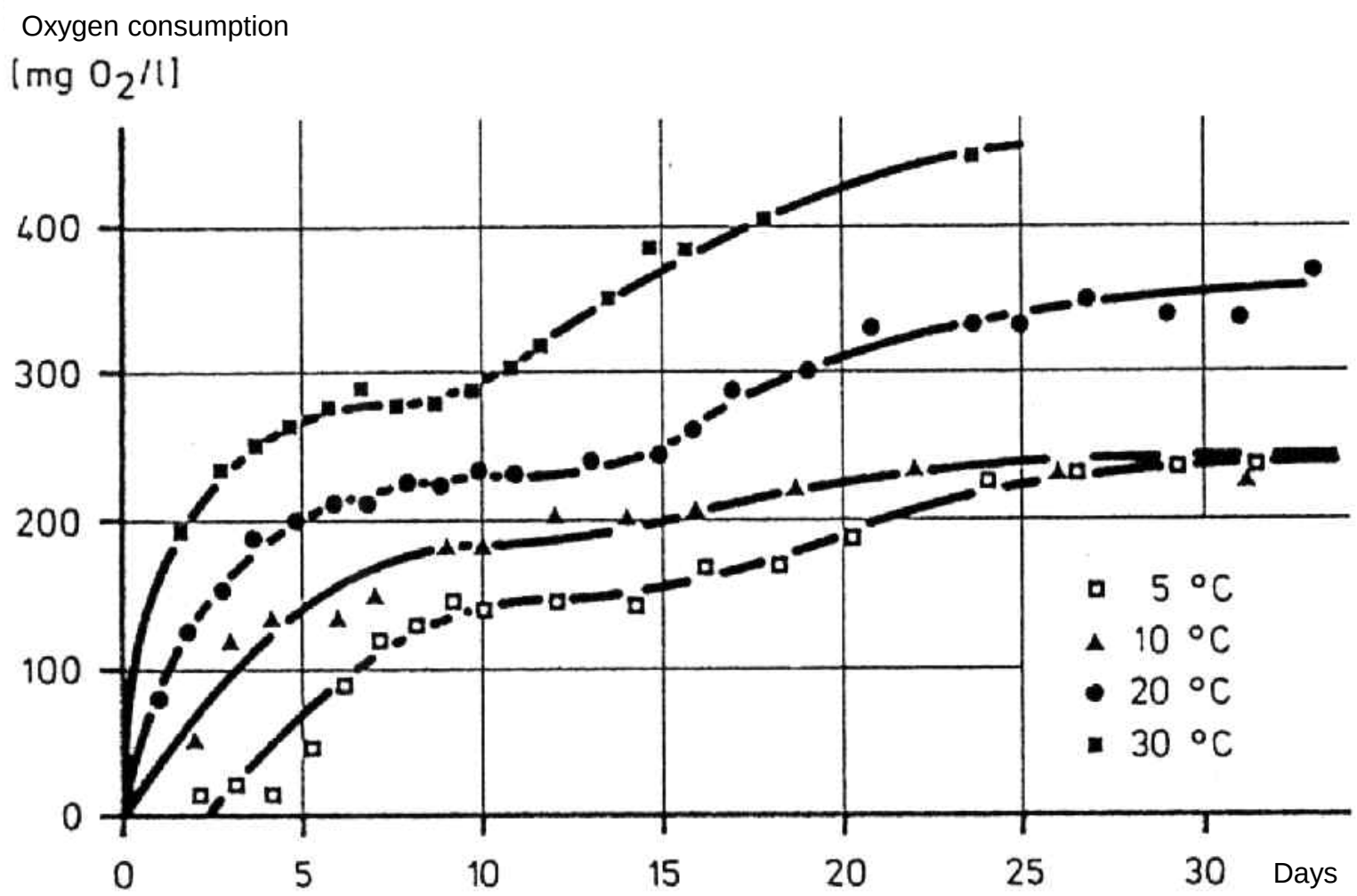
Parameter	Raw wastewater	Flow time in the primary settling stage with $Q_{h,DW}$	
		0.5 to 1.0 h	1.5 to 2.0 h
BOD_5	60	45	40
COD	120	90	80
DS	70	35	25
TKN	11	10	10
P	1.8	1.6	1.6

Example: Daily loads equivalent to 1.0 million people

Load = Specific load x Inhabitants
alternatively:
Load = Concentration x Flow

Raw wastewater:
BOD-load: $1 \times 10^6 \times 60$ (g/I · d)/1000 = 60,000 kg/d
COD-load: $1 \times 10^6 \times 120$ (g/I · d)/1000 = 120,000 kg/d
After sedimentation of 1.0 hour:
BOD-load: = 45,000 kg/d
COD-load = 90,000 kg/d

Process of the oxygen consumption (BOD_n)



Determination of the BOD

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The dilution method *(Verdünnungsmethode)*:

Wastewater is diluted with oxygen saturated water and inoculated with bacteria. After five days in an airproof bottle the residual oxygen content is measured. The difference of oxygen between beginning and end is a measure of the oxygen demand.

The manometric method *(Manometrische Methode)*:

A mixture of sewage and air is stirred up in an air tight bottle. The developing CO_2 is bound through NaOH or KOH. The fall of pressure can be used as a measure for the oxygen demand.

Determination of the BOD

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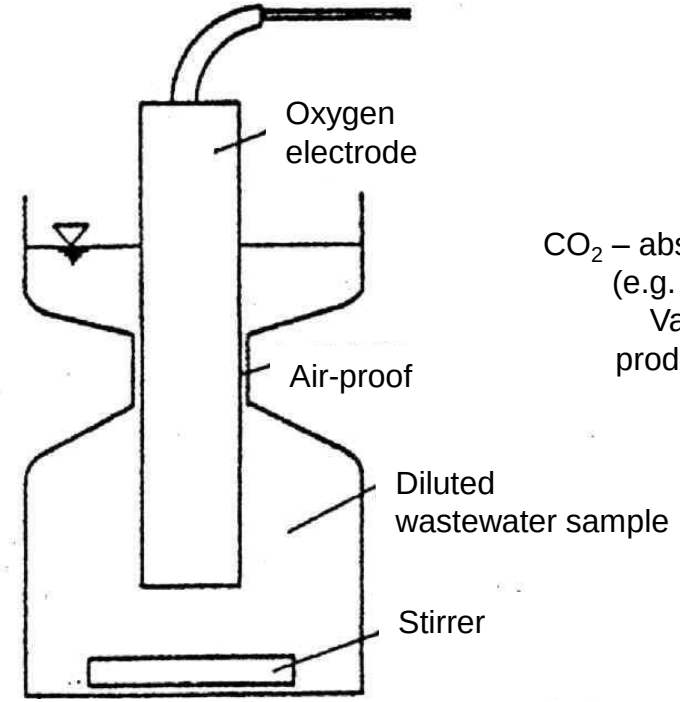
Sapromat method *(Sapromat Methode)*:

The negative pressure that is caused by O_2-consumption and CO_2-absorption initiates an impulse which starts the electrolytic production of oxygen which is fed into a measuring bottle.

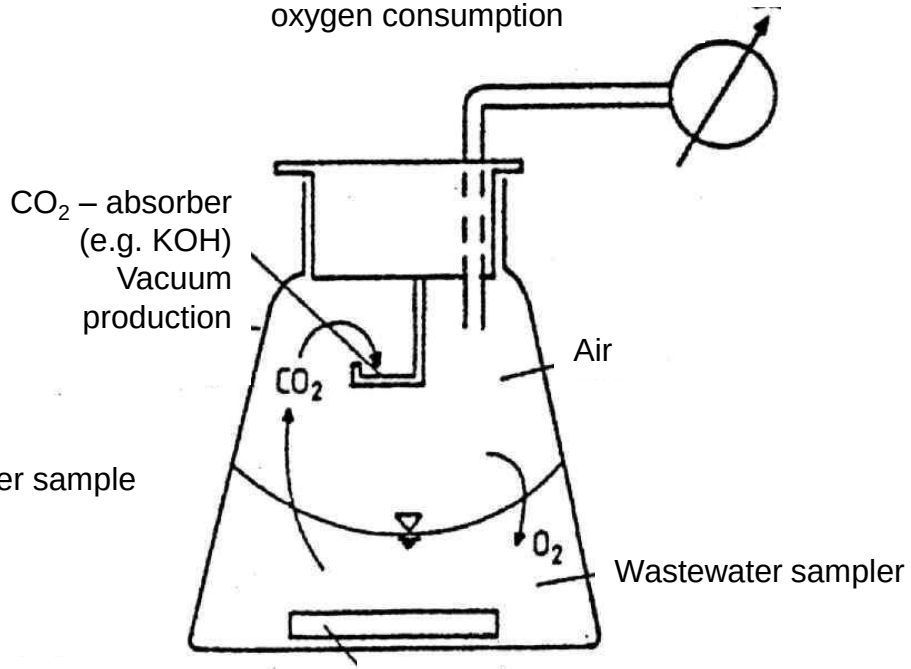
The quantity of impulses shows the consumed amount of oxygen. The advantage of this method over the first mentioned ones is that the oxygen consumption can be measured in the original waste water with constant concentration of oxygen and without limiting the measurement duration.

BOD - analysis methods



BOD bottle (e.g. Karlsruher bootle)

Manometry as a measure for oxygen consumption



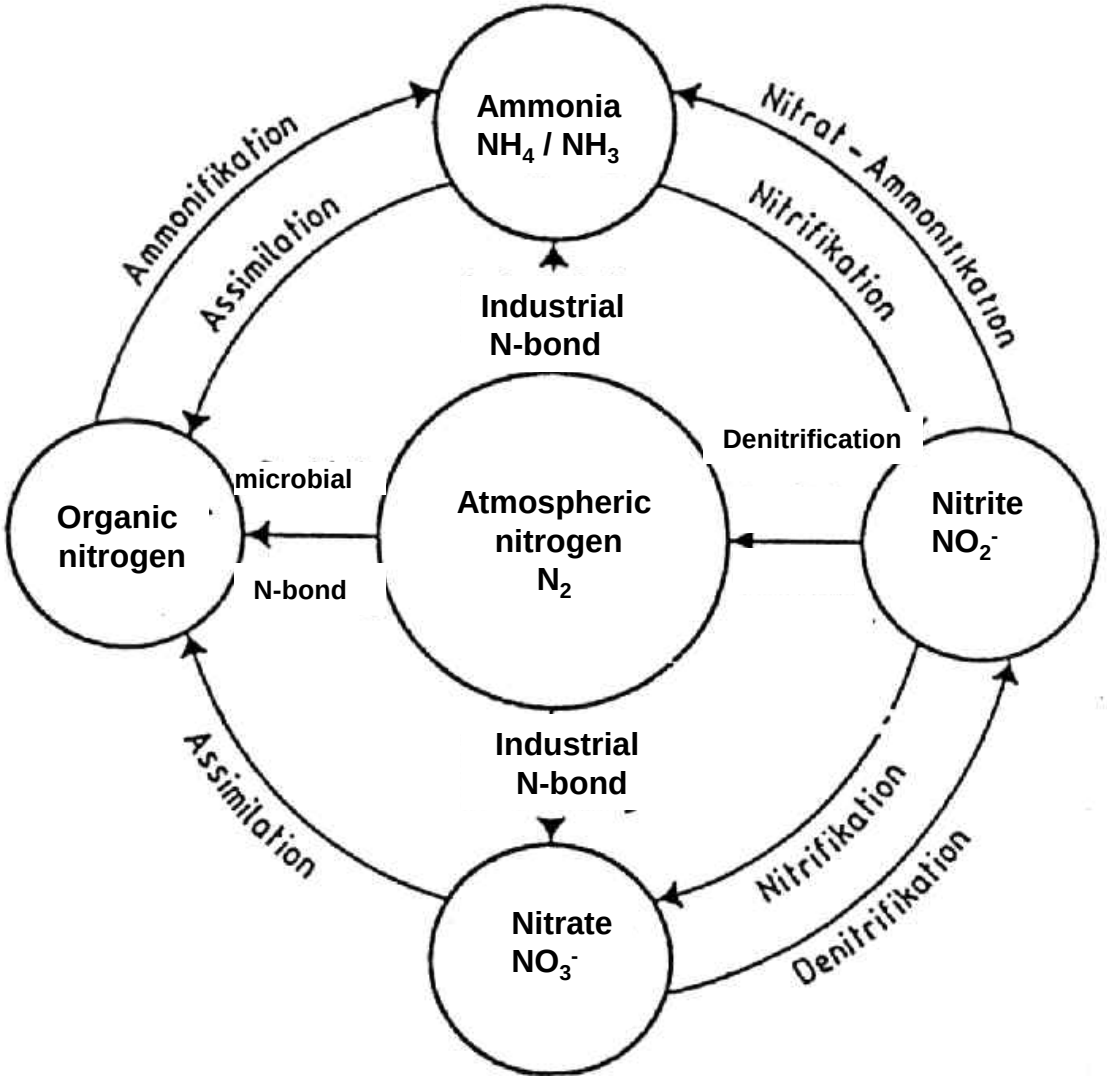
In comparison: Theoretical O_2-demand and COD

Substance	Theoretical O_2-demand [mg O_2/g]	COD [mg O_2/g]	[%]
Glucose	1067	990	93
Starch	1185	990	84
Phenol	2383	2340	98
Methyl alcohol	1500	1425	95

Comparison of different types of oxygen demand

Type of pollution	Oxygen demand due to the aerobic degradation of pollution
Degradation of 1.0 g of carbon in form of acetate:	2.67 gO_2 / gC
Degradation of 1.0 g of nitrogen in form of ammonium (nitrification)	4.57 gO_2 / gNH_4-N
Degradation of phytoplankton biomass developing out of 1.0 g of nitrogen	21 gO_2 / gN
Degradation of phytoplankton biomass developing out of 1.0 g of phosphorus	150 gO_2 / gP

Scheme of the global nitrogen cycle



Nitrogen (forms and occurring problems)

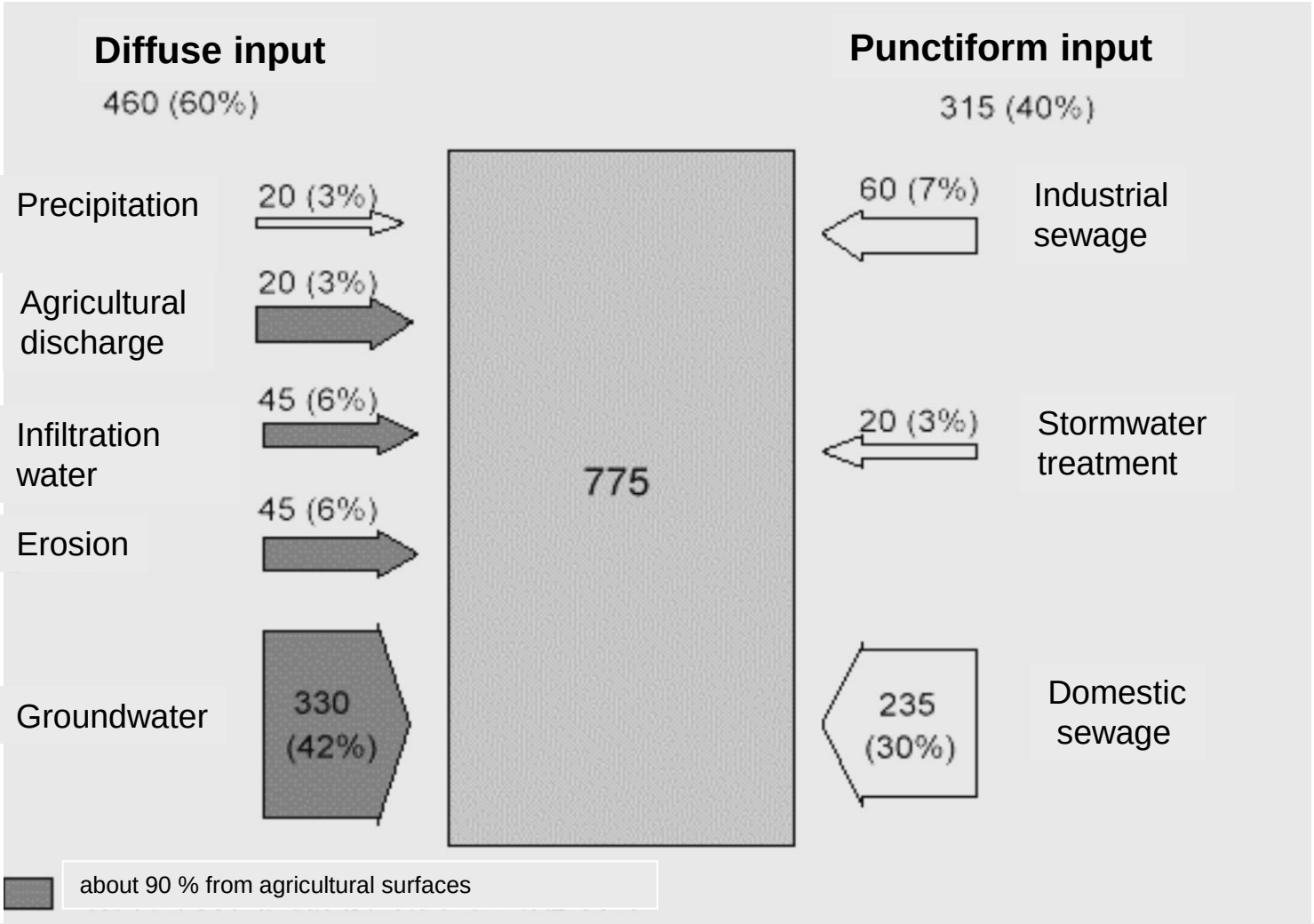
- **Organic nitrogen** (org. N):
  Low concentration, no problems

- **Ammonia** (NH_4):
  Oxygen consumption; equilibrium of dissociation with the fish poisoning ammonia

- **Nitrite** (NO_2):
  Fish poisoning

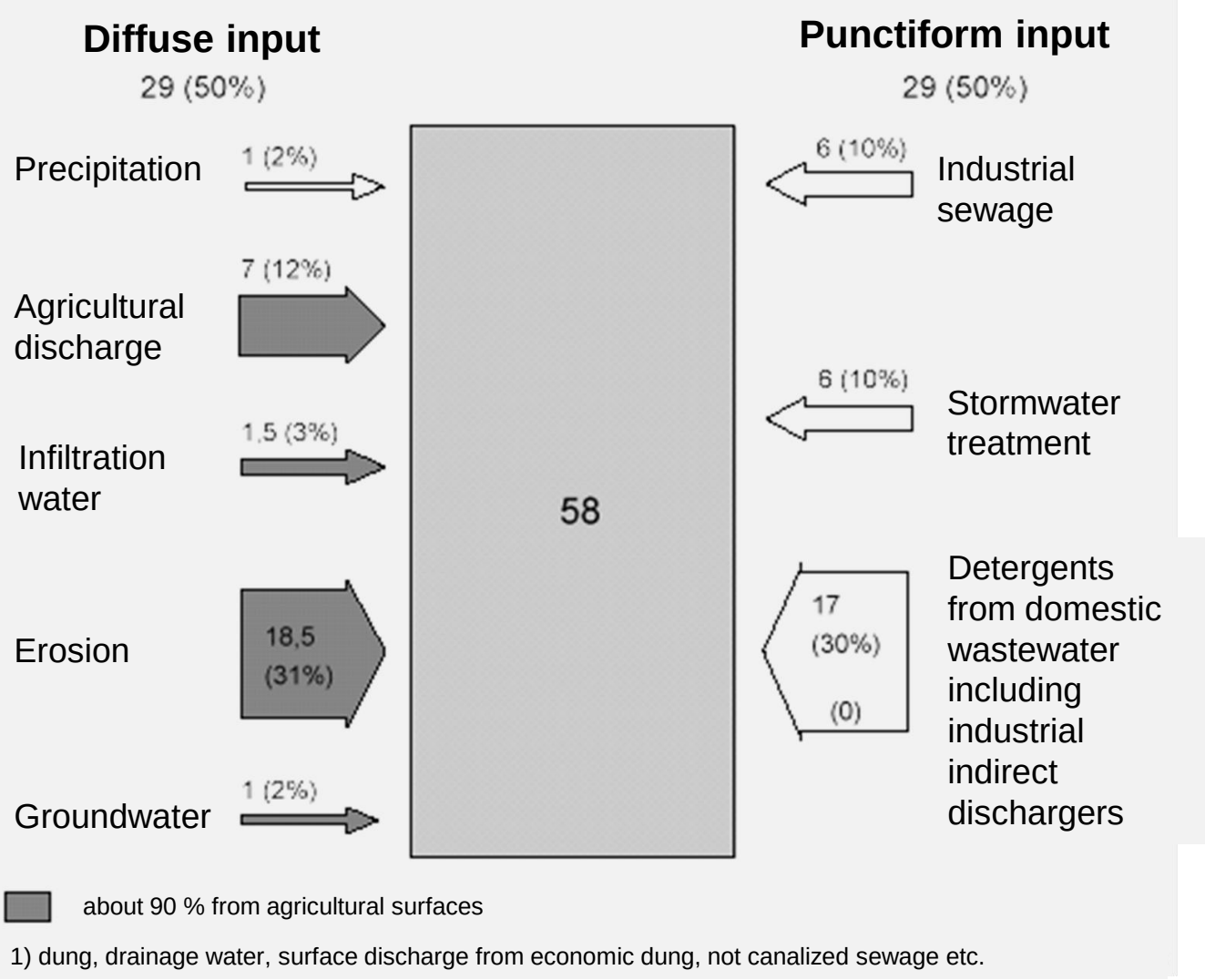
- **Nitrate** (NO_3):
  The amount of nitrate in drinking water is limited because of the danger of methaemoglobin and nitrosamine production.
  (critical limit: 50 mg NO_3/l)

Input of nitrogen in flowing waters [1000 t/a]



1) dung, drainage water, surface discharge from economic dung, not canalized sewage etc.

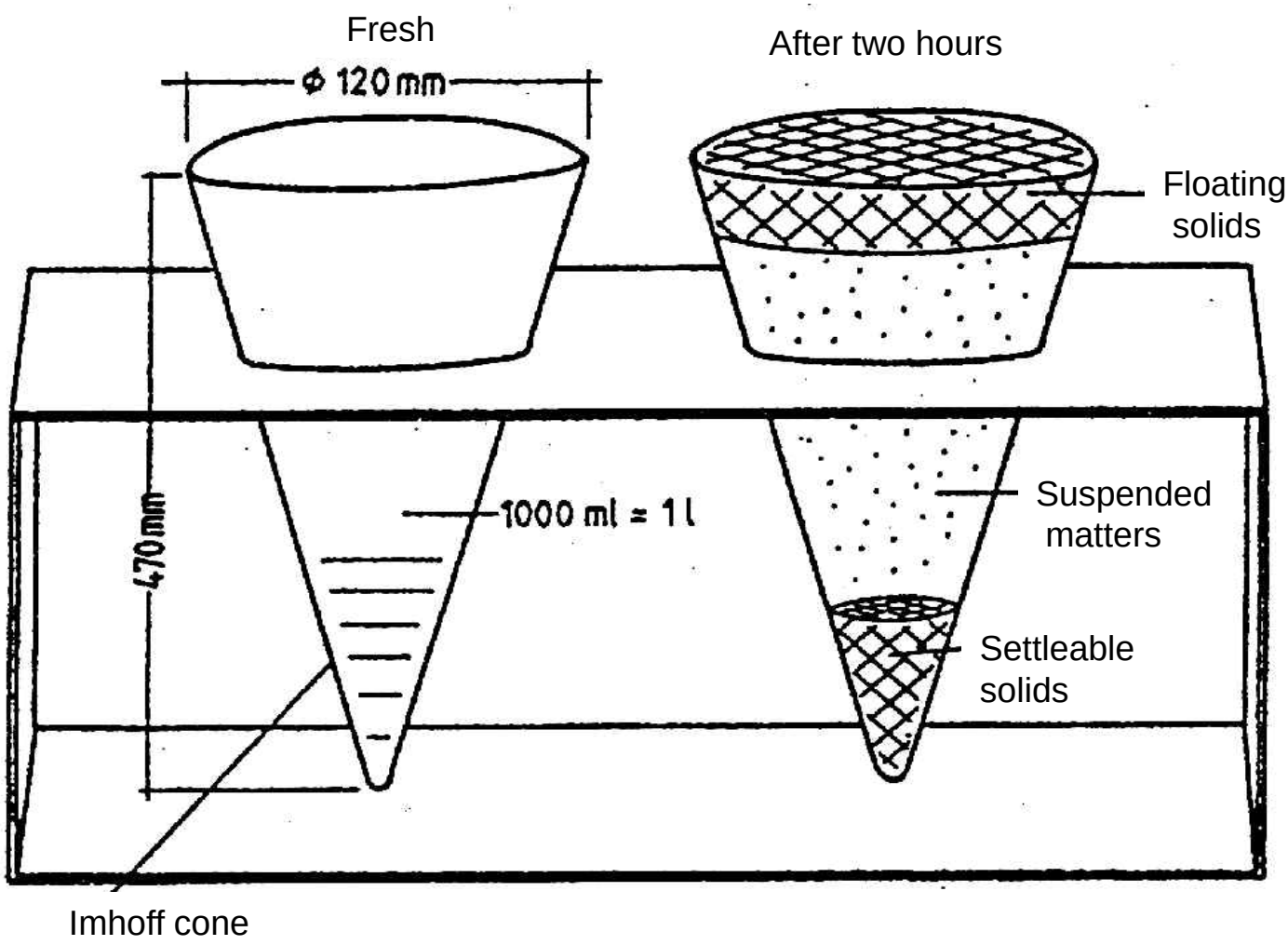
Input of phosphorus in flowing waters [1000 t/a]



Hazardous substances

- Poisonous (toxic) substances
- Long-lasting (resistant) substances, which accumulate in the environment and could have still unknown effects
- Accumulating (bio-accumulating) substances, which harm because of accumulation in animals, humans and plants (e.g. quicksilver)
- Carcinogenic substances
- Teratogenic substances
- Mutagenic substances

Determination of settleable solids



Lecture 12

Part: Requirements, Legal Basis/ Administrative Structures

Laws on Municipal Water Management

- Laws for the order of water resources (water resources act (WHG))
- The respective State Water Supply Law (e.g. Low Saxony Water Supply Law (NWG)) with self-monitoring regulation (for wastewater treatment plants and sewers)
- Wastewater Regulation (AbwV)
- Wastewater Levy Act (AbwAG)
- Sewage Sludge Spreading Regulation (AbfKlärV)

Laws on Municipal Water and Waste Management

- Waste Management und Recycling Act (KrW-/AbfG) with the General Administrative Regulations e.g. Technical Guideline for Residential Waste Glossary (TASi)

- Federal Immission Control Act (BImschG) and the German Clean Air Act (TA Luft)

- Enviromental Impact Assessment Law (UVP-Gesetz)

- European Union Directives

Minimum requirements according to the Appendix 1 of the Wastewater Regulation *(AbwV)* local communities

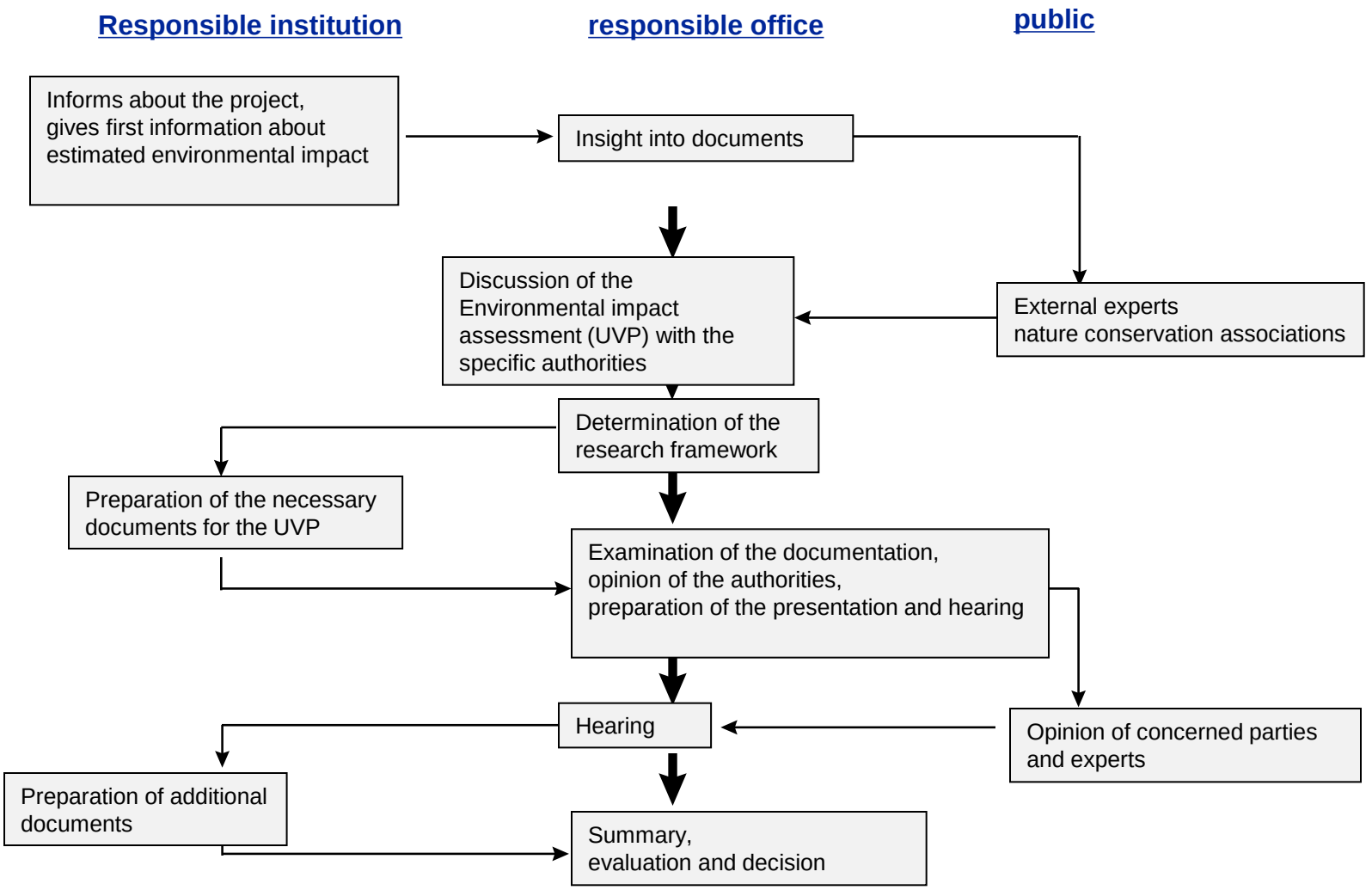
Minimum requirements according to the Wastewater Regulation – Appendix 1						
Size category	Based on 60 g BSB_5/(I*d)	COD mg/l	BOD_5 mg/l	NH_4-N*) mg/l	anorg. N*) mg/l	total-P mg/l
1	< 1,000	150	40	-	-	--
2	1,000 bis < 5,000	110	25	-	-	-
3	> 5,000 bis 10,000	90	20	10	-	-
4	> 10,000 bis 100,000	90	20	10	18**)	2
5	>100,000	75	15	10	13**)	1

*) This requirement applies to the condition of a waste water temperature of 12°C and higher during the process of the biological reactors in the wastewater treatment plant facilties. Instead of the condition of 12°C can take place time restrictions from 1st May to 31st October.

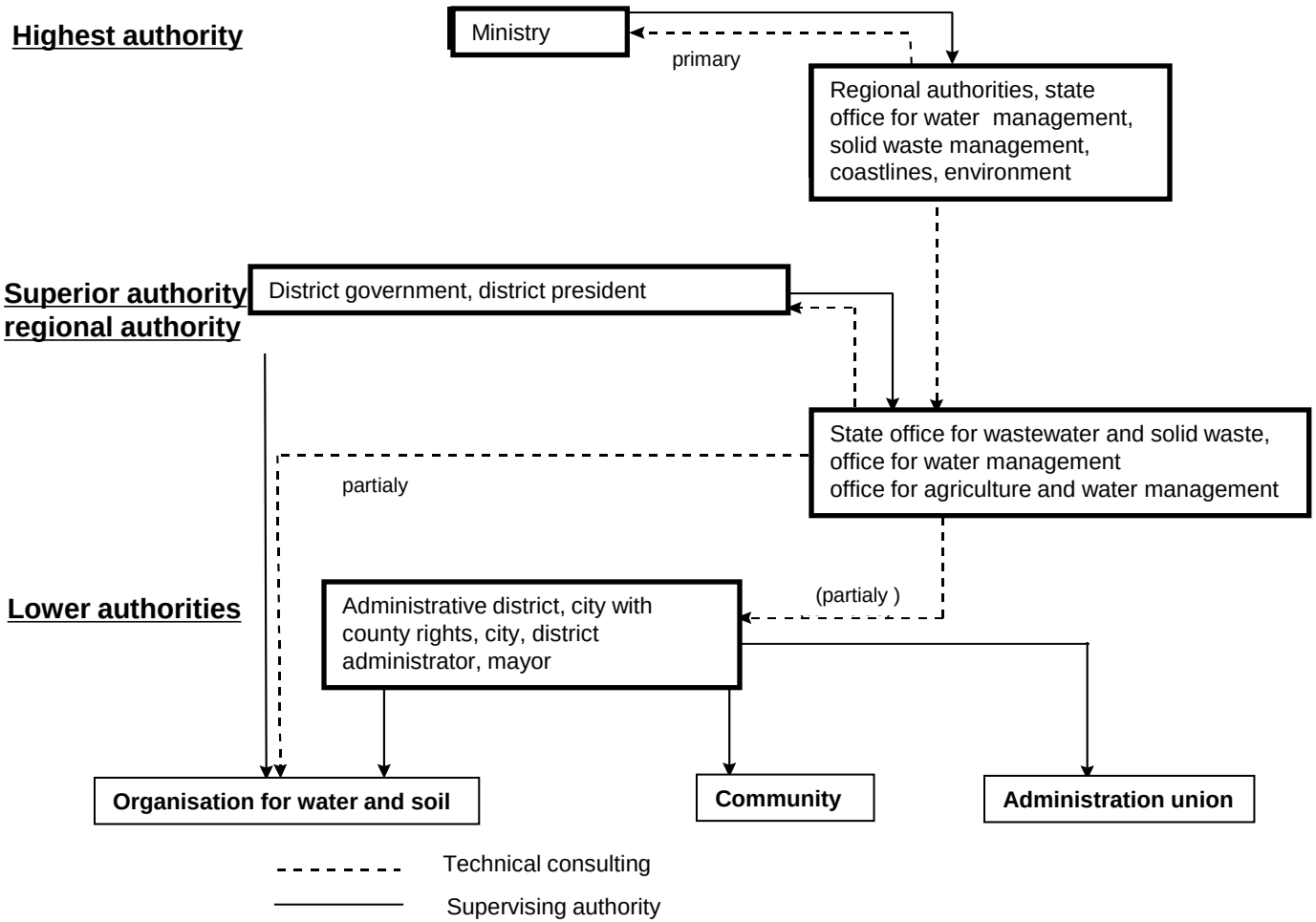
) **25 mg/l when the total N-daily demand is reduced by ≥ 70% by a period of sampling ≤ 24 h

Monitoring values:	2h composite sample or qualified random sample
Observance criteria:	not more than **one** of the last **five** inspections is higher than the critical limit, **maximum** by 100%

Process schematic of the environmental impact assessment



Water management administration structure



∗ not occurring in federal states (Slw. H., Saarl., Meck.-Vop., Brandenburg, HB, HH, ab 2004 in Nds.)
∗∗ StÄWA terminated in Lower Saxony since 1997