Bauhaus-Universität Weimar

in co-operation with DWA

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V.

Further education

1. Edition

Correspondence course
Water and the Environment

Subject matter

Basic process engineering in industrial wastewater treatment

Bauhaus-Universität Weimar

Basic process engineering in industrial wastewater treatment

1. Edition

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V.
(DWA)

WW 54 - Table of contents

4 Chemical / physical processes

5 Bioconversion

WW 54 - List of figures

1 Legal basis

2 Basis for planning environmental protection in industrial water management

3 Mechanical / physical processes

4 Chemical / physical processes

5 Bioconversion

WW 54 - List of tables

1 Legal basis

2 Basis for planning environmental protection in industrial water management

3 Mechanical / physical processes

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BAUHAUS-UNIVERSITÄT WEIMAR
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WATER AND THE ENVIRONMENT

WW 54

Basic process engineering in industrial wastewater treatment

1. Edition

Chapter 2

Basis for planning environmental protection in industrial water management

Chapter 2 - Table of contents

Chapter 2 - List of figures

Chapter 2 - List of tables

2 Basis for planning environmental protection in industrial water management

2.1 Integrating environmental protection into industrial processes

'The best wastewater is wastewater which doesn't occur in the first place'

True to the principle that 'the best wastewater is wastewater which doesn't occur in the first place', the aim is to organise production processes that (in the best-case scenario) generate zero wastewater, while keeping a critical eye on any cross-media effects (air, waste, energy). As well as being technically and economically feasible, production processes must make good ecological sense. [2]

Applying the 'best available techniques' (BAT)

The call to apply the 'best available techniques' (BAT) is a key element in the European Parliament and Council Directive on integrated pollution prevention and control (IPPC Directive, *Chapter 1.2.3 IE Directive (2010/75/EU)*). In Article 2 (12), the Directive defines 'best available techniques' as:

> *'... the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole:*
>
> ***'Techniques'** shall include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned*
>
> ***'Available'** techniques means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator*
>
> ***'Best'** means most effective in achieving a high general level of protection of the environment as a whole.'*

Environmental protection measures grouped by assignment to product or production

Environmental protection measures can be assigned to either the product or the production process, as shown in *Figure 2.1*.

Amongst other things, product-related environmental protection focuses on the resource consumption, functional properties and lifespan of the product, along with the means of recycling it or disposing of it. This 'product design' will not be described in any more detail here.

Production-related environmental protection

Production-related environmental protection refers to any measure that aims to reduce the amount of resources used for production and minimise emissions created by the manufacturing process.

Integrated and end-of-pipe measures

Environmental protection measures assigned to the production side can be split into integrated and end-of-pipe measures. In the case of end-of-pipe environmental protection, measures to reduce emissions are introduced downstream of the production process.

Process- or production-integrated procedures

Integrated measures are referred to as process- or production-integrated environmental protection (PIEP) in accordance with the level at which they are applied or the level at which they are effective.

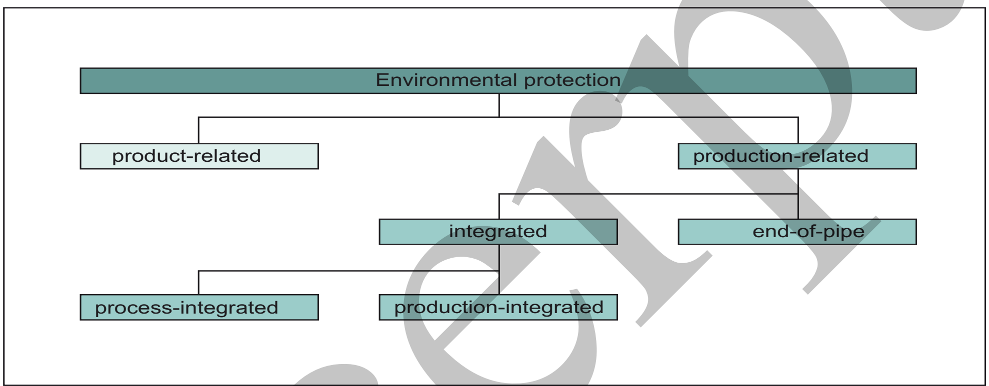

Fig. 2.1: Environmental protection in industrial water management

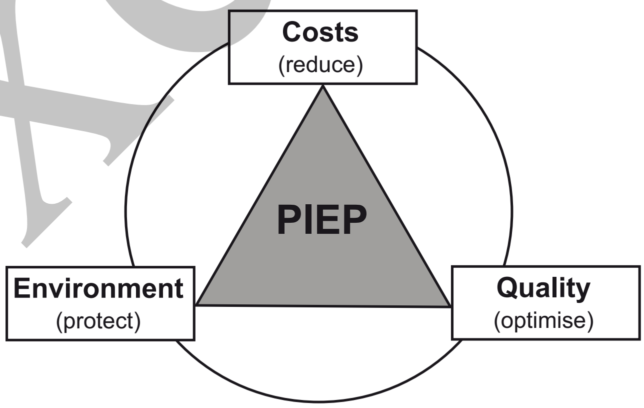

Fig. 2.2: PIEP objectives, Association of German Engineers (VDI) Guideline for 'Production-integrated Environmental Protection' [13]

Objectives of production-integrated environmental protection

Association of German Engineers (VDI) Guideline 4075 [13] sets out the objectives of production-integrated environmental protection (also known in English as 'cleaner production'):

- Low production costs in the long term
- Eco-friendly production

- Optimum product quality

Integrated environmental protection (i. e. process- and production-integrated environmental protection, or PIEP) and end-of-pipe solutions are among the measures undertaken in industrial water management; from an overall ecological perspective, precedence is given to process- and production-integrated measures.

In practice, it is impossible to view the various environmental protection measures (end-of-pipe, production-integrated, process-integrated) in a completely separate manner. Process-integrated and production-integrated environmental protection must simultaneously meet the needs of production and environmental protection. It is therefore vital to ensure close collaboration between advisers, planners, plant manufacturers and plant operators as well as with the permitting authorities.

Comparison of end-of-pipe und integrated environmental protection

Table 2.1 compares end-of-pipe with integrated environmental protection. This comparison makes it apparent that the environmental protection technologies to be deployed in most industries cannot remain exclusively 'end-of-pipe' or 'integrated' in the mid- to long term, but that combinations of both will become necessary depending on the specific situation of the respective enterprise.

Table 2.1: Comparison of end-of-pipe and integrated environmental protection measures, according to [9] and [13]

	End-of-pipe environmental protection	Integrated environmental protection
Objectives	Low production costs in the here and now Remedial environmental protection measures	Low production costs in the long term Eco-friendly production
Approach	Measures are introduced post-production: Minimal investment in terms of research, development and adaptation Minimal technical risk (end-of-pipe technologies are standard) Sectoral; possible shifting of pollutant problem to other environmental media	Optimises the production process in terms of process- and enterprise-related material flows and measures Extensive research and development Competitive advantage due to funding production and product-integrated innovations Spans different industries and media Saves on resources Saves on disposal costs Saves on operating and maintenance costs
Implementation	Lowering of emission limit values leads to rising operational costs and necessitates new investment once a certain level is reached Simple to retrofit existing plants	No problems when limit values are tightened Reduces or prevents environmental contamination
	High capital expenditure regardless of production volume End-of-pipe installations require a certain minimum capacity and thus constitute a hindrance to process-oriented innovation	(Possible) negative impacts on the manufacturing consortium (Possible) malfunctioning in operational end-of-pipe installations (e. g. in biological wastewater treatment) Improvements to reaction and/or process engineering in the interests of production-integrated environmental protection are not always possible

2.1.1 End-of-pipe environmental protection

Procedures introduced downstream of production

End-of-pipe environmental protection is understood to include any process added downstream of production (hence the term 'end-of-pipe') in order to reduce polluting emissions. Such activities are also referred to as secondary measures.

Problem: mixing of different partial flows of wastewater

Measures introduced downstream of the production process can lead to the mixing of different partial flows. As demands on the level of purification become more stringent, the effort and outlay required also increase to a disproportionate degree. End-of-pipe measures always entail additional investment and operating costs, which means they are considered unproductive from an operational perspective. On the other hand, the advantage of end-of-pipe measures is that they interfere very little, if at all, with existing production processes.

The shift from end-of-pipe measures towards process- and production-integrated measures is being prompted by legal regulations as well as economic aspects.

Integrated environmental protection measures are firmly embedded in water law, insofar as a permit for the discharge of wastewater into a water body may only be issued if the pollution load is kept as low as possible and if water-saving procedures are deployed during production. Depending on the sector, the concentration of hazardous substances is already limited at the actual site of wastewater accumulation [1]. This means that the ecological and economic sense of using end-of-pipe technologies is increasingly being called into question [5].

Deployment of best available techniques

The IPPC Directive makes issuance of a permit contingent upon deployment of the best available techniques. According to Appendix 1, Item 3 of the Federal Water Resources Act (WHG) this is *inter alia* assumed to be fulfilled if one promotes the *'recovery and recycling of the substances generated and used in the individual operations, along with any waste created'.*

Integrated measures are increasingly being deployed in industry

Integrated measures are therefore being increasingly deployed in the industrial sector, but without being able to entirely dispense with end-of-pipe measures. In industrial production, emissions are often neither completely preventable nor utilisable; nor do process-integrated and cleaner technology measures always represent an economically viable solution. This is where in-house 'end-of-pipe technologies' come into play. They can be used to pre-treat the emissions to a level at which discharge can take place, for instance in the form of an indirect discharge.

2.1.2 Integrated environmental protection

Measures which prevent and reduce emissions during production as well as preserving resources

Integrated environmental protection is understood to mean any measure aimed at preventing and reducing emissions and minimising consumption of resources at the production stage. Its purpose can be characterised in three key words (prevent, reduce and recycle), which is why it is also referred to as primary measures or precautionary environmental protection. For some years now, these imperatives have increasingly been debated in the context of promoting sustainable development; nevertheless, in many industries they have always been one of the key tasks of product and production planning for economic reasons alone. Integrated measures often need considerable investment, although they also offer opportunities to save on costs thanks to lower resource consumption (e. g. water and energy, raw materials) and reduced emissions. This being so, integrated environmental protection constitutes a mid- to long-term economic objective for companies. However, one disadvantage of integrated environmental protection from a production point of view is that it frequently calls for expensive intervention in individual processes and/or production as a whole.

Production-integrated and process-integrated measures

A distinction is made between production-integrated and process-integrated environmental protection.

Production-integrated measures mean that one should reuse unavoidable waste materials as input or auxiliary materials (in other processes if at all possible). The intention with production-integrated environmental protection is for emissions to be reprocessed for subsequent reuse.

Process-integrated measures generally entail environmentally relevant improvements or adjustments to procedures such as the development of low-residue or residue-free operations. Process-integrated environmental protection therefore takes precedence over production-integrated environmental protection.

Combination of the two variants found in practice

In practice, it is impossible to view process- and production-integrated environmental protection measures in an entirely separate way. The ideal solution for an individual company generally involves a combination of the two, adapted to the specific situation of the said company. Moreover, the success of the overall concept can often only be achieved via co-ordinated interaction of process- and production-integrated measures. For example, successful flow management through production-integrated concepts not only calls for the right choice of separation and concentration procedure, but also the process-integrated selection of appropriately durable input material.

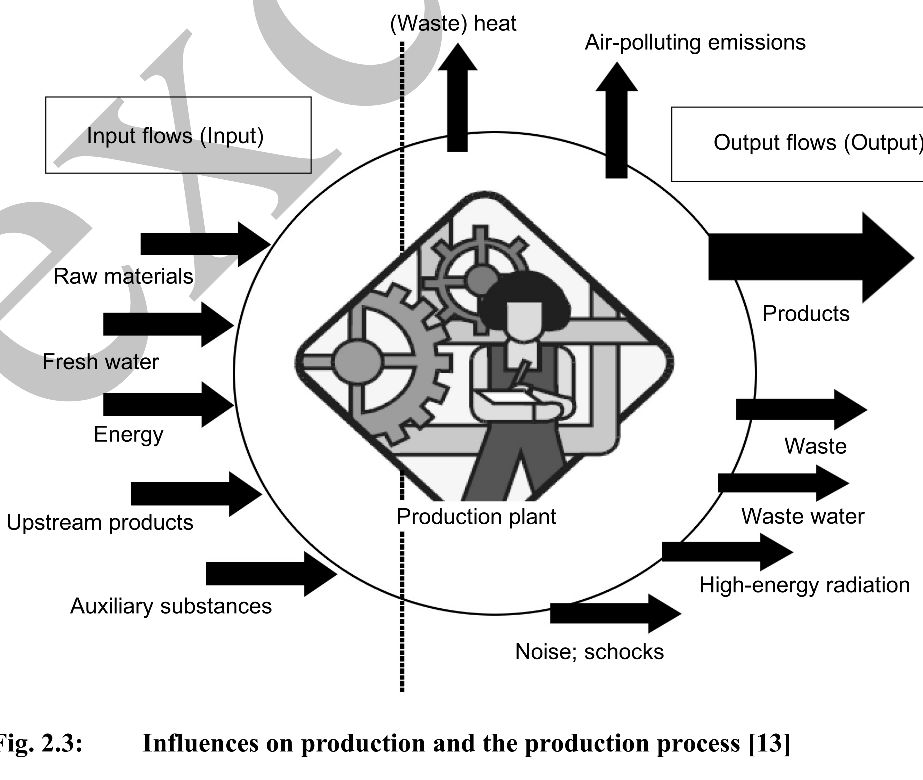

Fig. 2.3: Influences on production and the production process [13]

2.1.2.1 Production-integrated environmental protection

Avoidance measures take priority over recycling, which in turn takes priority over disposal

A fundamental principle of production-integrated environmental protection is that avoidance measures should take priority over recycling and disposal measures. As with end-of-pipe procedures, production-integrated measures also involve the subsequent treatment of process-induced emissions. However, an attempt is made to process them for recycling. The objective is therefore to reduce as far as possible the proportion of non-recyclable waste substances and the wastewater to be discharged. Hence the main areas focussed on by production-integrated measures are:

- Multiple re-use of non-avoidable process, washing and rinsing water
- Closed-loop cycles
- Recycling of substances
- Resource recovery

Add-on procedures integrated into production

In practice, add-on procedures similar to end-of-pipe measures are deployed to achieve this, but are integrated into production rather than being introduced downstream. They supplement either individual steps in the process or areas of production, and are therefore not the same as end-of-pipe technologies. The main procedures used are:

- Selective separation
- Concentration
- Purification
- Regeneration
- Closed-loop cycles

They are deployed to separate, purify or concentrate non-converted input and auxiliary materials which have been carried over, along with by-products, solvents, etc. to such a degree that they can be returned to a process where they are reutilised. This may be the same process or a different one, either in the same factory or in other companies or industries.

Economic viability

The economic benefits arise from:

- recycling the residual substances *and*
- reducing disposal costs

A major precondition for the technical and economic success of production-integrated operations is that they take individual steps in the process and partial flows as their starting point; the reason for this is that in many cases the outlay required to recover or selectively separate residual products becomes technically or economically unviable once the material and wastewater flows from individual process stages or different processes have been merged and blended.

VDI Guideline 4075

VDI Guideline 4075, particularly intended for small and medium-sized enterprises (SMEs), offers structured guidance on cleaner production / product-integrated environmental protection.

2.1.2.2 Process-integrated environmental protection

Objectives

Process-integrated environmental protection measures normally entail environmentally relevant adjustments or the complete reorganisation of processes, which means radical re-orientation as opposed to the 'end-of-pipe philosophy' pursued up until that point. The main objectives are to:

- minimise raw material and energy consumption
- optimise product yield *and*
- bring about low-emission or, better still, emission-free processes and installations

Achievement of these sub-objectives goes a long way towards accomplishing environmentally sound production. The cost savings they bring are likely to mean faster amortisation periods and hence the most economically viable solutions. On the other hand, the complete redesigning of a process to accommodate the requirements of process-integrated environmental protection generally calls for time- and cost-intensive research and development, and, in some cases, even the top-to-bottom reconstruction of production plants. In view of this, process-integrated environmental protection is to be seen more as a mid- to long-term strategy.

2.2 Basis for planning

Before implementing in-house environmental protection measures it is necessary to appraise the operational wastewater situation. On this basis, plans can be drawn up for a working wastewater concept. This can be undertaken in the following stages:

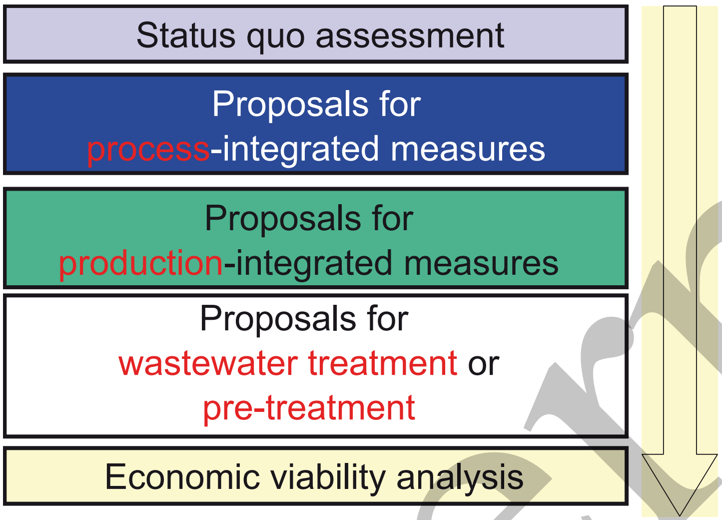

Fig. 2.4: Procedure for selecting in-house environmental protection measures

2.2.1 Status quo assessment

Exact assessment of the water and wastewater situation

Prior to any plans for in-house measures to reduce wastewater volume and loads, it is important to take exact stock of the water and wastewater situation in the respective plant. The production procedure must be described and then analysed with regard to the points at which water is required, and where wastewater and pollutant loads occur. In addition, the quality of service water required for each production process must be determined.

Worksheet A 712

The data and specifications required to plan a wastewater treatment plant are explained in more detail below. Data is to be compiled according to DWA Worksheet A 712 [4].

Operating data

Operating data:

1. Exact address of the company, plant manager, water protection officer
2. The water authority responsible
3. Production specifications:
    - Production programme
    - Production procedure
    - Production times

- Downtimes and servicing periods
- Seasonal periods
- Personnel situation
- Programme of shift work
- Anticipated increases or changes in production

Water use, specific water demand

Water use (m^3/h, m^3/d, m^3/a)**, specific water demand**

- Nature of water supply and water use
- Drinking water
- Boiler feed water
- Production water
- Water remaining in the product
- Water evaporation
- Water cycles
- Levels of recirculation and clarification

Wastewater partial flows

Wastewater partial flows:

Due to their many products and production processes, industrial enterprises create a wide range of wastewater partial flows for which (depending on the industry) certain terms have been coined, e. g. *Lutterwasser* or Lutter water to denote the bubbly residue from a second stage of refinement in the distillation process). The wastewater partial flows listed below represent some of the main sources of wastewater, although this is not to say that each occurs in every enterprise.

- Rainwater
- Wastewater from sanitary and staff facilities
- Cooling water
- Wastewater from in-house water processing
- Production wastewater
- Washing and flume water
- Fruit water
- Vapour condensates
- Cleaning effluents

Individual partial flows are represented according to:

- wastewater flow (m^3/h, m^3/d, m^3/a)
- pollution parameters (e. g. pH value, settleable solids, COD, BOD_5, nitrogen and phosphorous) and concentrations thereof (g/m^3)
- pollution loads (kg/h, kg/d, kg/a).

Further data:

Further data

Description of the nature, composition, volume, site of occurrence and fate of liquids, sludges or solid matter which must not be discharged along with the wastewater

Description of existing installations for the discharge of rainwater and wastewater and for wastewater treatment (plans, depreciation and amortisation of technical equipment, degree of efficiency)

Description of the rainwater catchment areas and the sewage system:

- Separate sewage system
- Mixed system *or*
- Rainwater discharge and/or percolation

Description of any possible flooding scenario:

- Flood area boundaries *or*
- Backwater level in the sewage system

Description of the disposal situation for recyclable materials, waste and sludge:

- Fate of substances *and*
- Permits

Description of possible water protection zones.

Figure 2.5 shows a detailed model for describing installations and sub-processes, and for collecting data.

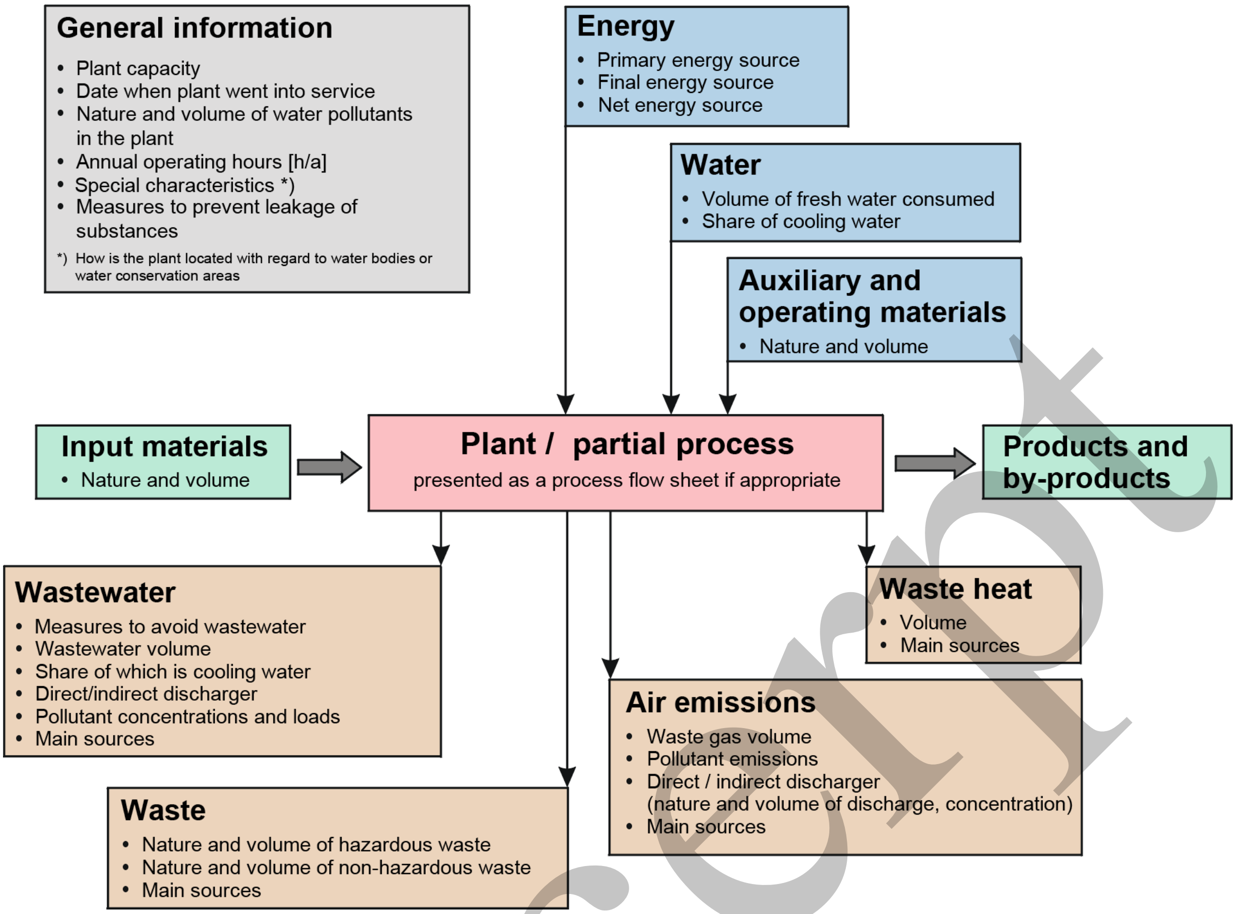

Fig. 2.5: **Model for describing installations / partial processes and collecting data [14]**

2.2.1.1 Wastewater partial flows

Surface water

Distinction according to degree of contamination

Depending on the size / extent of various paved-over areas, surface water can at times constitute a large proportion of the wastewater volume. It makes sense to distinguish between minimally contaminated rainwater (e. g. from the roofs of large public buildings) which can be discharged directly into a rainwater drainage system or water body, and rainwater from commercial premises (likelihood of product spills from the loading / filling of vehicles as well as vehicle-related contamination) which requires pre-treatment or must be fed into the wastewater sewer.

Wastewater from sanitary and staff facilities

Wastewater from sanitary and staff facilities resembles domestic wastewater and should therefore normally be captured separately from production wastewater and fed directly into the municipal wastewater system. Treatment in the factory's own treatment plant is, however, also possible. If there is a large factory canteen, wastewater from this source should then be considered separately.

If one looks at wastewater volume, one can expect around 40–80 litres per employee and shift; the quality of the plumbing fixtures and the dirt load at the workplace (e. g. requirement to use showers) can have a major impact. *Wastewater volume*

The load per employee and shift can be assumed to be 20–40 g BOD_5, 3–8 g N_{total} and 0.8–1.6 P_{total} *Wastewater load*

Cooling water

If cooling is necessary and it is achieved by using water, a distinction is made between a continuous flow cooling process (involving very high water consumption) and a closed-loop process (concentration of water constituents). *Continuous flow and closed-loop procedures*

It is impossible to generalise about the volume of cooling water that occurs, due to the major discrepancies in cooling demand from industry to industry. Depending on the salinity of the cooling water, a rule of thumb for a closed-loop cooling tower is that approx. 3–5 % of the circulation water needs to be drained from the system as wastewater (blowdown) in order to prevent excessive concentrations.

If leakages can be ruled out in a continuous flow cooling tower, and provided that no chemical additives are used, the composition of the wastewater does not change, except for an increase in temperature. In a closed-loop cooling tower, the concentration of the water constituents increases as a result of evaporation.

Wastewater from in-house water treatment

Wastewater from in-house water treatment may occur when a company obtains its own drinking water from well water, or during the softening, decarbonisation or desalination of water. The water's constituents depend on the quality of the raw water and the treatment methods used.

Wastewater flows from production

Production wastewater is a generic term that covers a number of partial flows. A more precise specification is only possible in relation to the industry concerned. The wastewater flows listed below are to some extent considered either as a separate flow or as part of the production wastewater.

In many sectors of the food industry, *produce washing water* is simultaneously used as *flume water* to transport the produce. *Produce washing water & flume water*

Fruit water

Fruit water is the term used for the water contained in products to be processed, such as potatoes from which water is extracted during starch production.

Vapour condensates

Vapour condensates are quantities of wastewater which have been re-condensed following removal during an evaporation or drying process.

Cleaning effluents

Cleaning effluents result from the washing of production lines (pipes, containers, etc.), the cleaning of production premises, and the cleaning of containers (e. g. when washing bottles).

Water demand or wastewater flow per product unit

Specific water demand

From the data on water demand and/or wastewater flow established during the status quo assessment, it is possible to calculate the specific volumes of water required or wastewater produced, i. e. the volumes of water demand or wastewater per product unit:

$$\text{spec. } Q = \frac{Q}{P} \tag{2.1}$$

spec. Q	Specific water demand [m^3/kg]
Q	Water demand [m^3/d]
P	Product unit, e. g. mass [kg/d]

Specific wastewater flow

The wastewater flow is either measured directly or ascertained via the following flow balancing model:

$$\text{spec. } Q_{ww} = \frac{Q - Q_{enter\ p} - Q_{ev} - Q_{drip} + Q_{leave\ p}}{P} \tag{2.2}$$

spec. Q_{ww}	Specific wastewater flow [m^3/kg]
Q	Water flow [m^3/d]
P	Product unit, e. g. mass [kg/d]
$Q_{enter\ p}$	Flow of water entering the product [m^3/d]
Q_{ev}	Losses through evaporation [m^3/d]
Q_{drip}	Drip losses [m^3/d]
$Q_{leave\ p}$	Flow of water leaving the product [m^3/d]

2.2.1.2 Wastewater constituents

Representative sampling and chemical analysis of the respective partial flows

In addition to the volume of water, the nature and degree of the wastewater pollution are particularly important. Representative sampling and chemical analysis are called for in order to determine the concentrations of pollutants in the different partial flows of wastewater. The wastewater constituents or parameters to be analysed here depend on the respective industry and purification target, and must be identified from case to case.

The main wastewater constituents are summarised below, along with their significance in terms of conserving the value of production facilities and their influence on wastewater treatment measures.

Temperature

Influence on choice of construction materials

Temperature primarily influences the choice of construction materials. High temperatures damage certain plastics and may adversely affect seals / joints, etc. This is why the temperature of wastewater that is discharged into municipal sewage systems needs to be controlled. Germany, for instance, usually stipulates a standard discharge temperature of < 35 °C. In addition to chloride, the oxygen content plays an important role in the corrosion of steel components. Furthermore, the outgassing of volatile substances from wastewater is facilitated at high temperatures.

Influence on biological wastewater purification

A raised temperature exerts a positive influence on biological wastewater purification since the microbial activity increases as the temperature rises. On the other hand, excessive and strongly fluctuating temperatures exert negative effects. In the case of aerobic wastewater purification, the oxygenation capacity of the aeration systems falls as the temperature rises.

pH value

Influence on the choice of construction materials and the biological wastewater purification process

In a similar way to the temperature, the pH value influences the choice of construction materials and the activity of microorganisms. In order to prevent damage to sewage systems and downstream sewage plants, the standard practice in Germany is to ensure that the pH value of the discharged effluent remains between 6.5 and 10.

A relatively neutral pH value provides the best conditions for many microorganisms. Anaerobic wastewater treatment processes are especially susceptible to fluctuations in the pH value.

In many cases, the existence of a biological treatment stage removes the need for chemical neutralisation: organic acids can be biologically degraded, while alkalis are neutralised by the CO_2 emitted during this process. This does not apply to mineral acids.

Interfering materials

Interference with subsequent treatment stages

In the context of wastewater treatment, interfering materials are understood to mean larger inorganic particles which are biologically inert and need to be removed via a sieve or grit chamber in order to prevent damage, blockages or deposits in subsequent purification stages. These materials can include glass shards, bottle tops, plastic parts, cigarette butts, sand and so forth, as well as non-recoverable production residues.

Particulate solids

Influence on quantity of organic substances

The amount of particulate solids in wastewater crucially influences the quantity of organic substances it contains. A distinction is made between *settleable solids* (which do not include *suspended solids* or *floating solids*), *filterable solids* in whose case membrane filtration (0.45 mm pore size) can capture all the corresponding particulate solids, and *dry residue,* which includes all the particulate and dissolved matter produced via water evaporation.

Organic substances (carbon)

Organic substances constitute the main form of pollution in most food industry plants. In order to avoid direct oxygen consumption in the water bodies into which the effluent is discharged, it is important to eliminate such substances to the greatest possible extent. A multiplicity of sum parameters can be used to determine the amount of organic material present. A distinction is made between BOD, COD, TOC, DOC, etc. (see *Chapter 5 Bioconversion*). However, these sum parameters do not give any indication of the nature of the organic substances.

COD (chemical oxygen demand)

COD (chemical oxygen demand) is increasingly becoming the most important parameter because it provides rapid results, which is not the case with BOD_5 (biological oxygen demand over 5 days). The use of cuvette tests enables one to ascertain COD very inexpensively and with a minimum amount of time and effort.

COD/ BOD_5 ratio

The COD / BOD_5 ratio is an important value when assessing the biodegradability of a particular wastewater. If the ratio is less than 2:1, the wastewater is referred to as 'easily biodegradable'. 'Refractory organic substances' are those which cannot be effectively removed via biological degradation.

Population equivalent: inhabitant-specific loads

The term population equivalent [PE] is used to compare the wastewater load of an industrial plant with that of a municipality or another industrial enterprise. To this end, the load of a given business is related to the corresponding specific wastewater load generated by a single inhabitant [g/(inhabitant·day)]. *Table 2.2* summarises inhabitant-specific loads according to Worksheet A 131 [3].

Sample calculation 2.1:

- A business delivers 800 m^3/d wastewater
- Average BOD_5 concentration:
  700 g/m^3 BOD_5
- BOD_5 pollution load:
  L_{d,BOD_5} = 800 · 700 / 1000 = 560 kg/d
- Population equivalent in relation to BOD_5:
  560 · 1000 / 60 = 9.333 PE

Table 2.2: Inhabitant-specific loads in g/(inhabitant·day), which are not exceeded on 85 % of days [3]

BOD_5	60
COD	120
Filterable solids (TS)	70
Total Kjeldahl nitrogen (TKN)	11
P	1.8

The inhabitant-specific loads are also a cost-relevant parameter when introducing wastewater charges based on pollution loads or 'heavy polluter' surcharges for indirect dischargers [11].

Nutrient elements (N, P)

Eutrophication problem

Excessive amounts of nitrogen compounds and phosphorous can cause massive growth of algae and aquatic plants in water bodies and thus lead to eutrophication problems, so it is important to broadly eliminate these nutrients in susceptible regions of the European Union before discharging wastewater into water bodies.

Sufficient degradable carbon compounds must be present if one is to eliminate nitrogen and phosphorous by using biological means. It is therefore not merely the concentration of these substances in the industrial wastewater that is important, but also the ratio to the BOD_5 or COD.

Addition of N and P to some types of industrial wastewater - minimum nutrient ratio

Some kinds of industrial wastewater have such a low nitrogen and/or phosphorous content that nitrogen (in the form of urea) and/or phosphorous (as phosphoric acid) must be added in order to obtain the necessary minimum nutrient ratio for the growth of microorganisms.

Hazardous substances

Hazardous substances is a generic term used for those substances or groups of substances contained in wastewater which must be regarded as dangerous because they are toxic, long-lived, bioaccumulative, or have a carcinogenic, teratogenic or mutagenic impact (see: *Chapter 1.6.2 Pollutants, priority substances, hazardous substances*).

Significant substances in industrial wastewater

The following substances are particularly important in industrial wastewater:

- Adsorbable organohalogens (AOX), extractable organohalogens (EOX)
- Chlorinated hydrocarbons (CHCs) and halogenated hydrocarbons (HHCs)
- Hydrocarbons (benzene, phenol, and other derivatives)
- Heavy metals, and in particular mercury, cadmium, chromium, copper, nickel, zinc
- Cyanides

Concentration is crucial

Whether or not a substance is regarded as toxic or hazardous *(see definition above)* primarily depends on its concentration. Many heavy metals are trace elements that are required to sustain life, yet they are toxic in higher concentrations.

Dutch classification system for the toxicity of wastewater

The Dutch classification system for the toxicity of wastewater [10] is based on the percentage of wastewater added to the test environment; it uses the EC/LC_{50} method. If 50 % of the test organisms in the wastewater die of acute poisoning (LC_{50}) even after the wastewater has been diluted more than 100-fold (i. e. < 1 vol. %), the wastewater is classified as 'acutely toxic'. The full range of categories is:

- Acutely toxic < 1 vol. %
- Highly toxic 1–10 vol. %
- Toxic 10–50 vol. %
- Minimally toxic 50–100 vol. %
- Not toxic > 100 vol. %

The legal provisions regulating hazardous substances are very extensive in Germany. This means that certain industrial sectors not only have to comply with stipulations relating to the overall quality of discharges during operations, but may also be obliged to meet further requirements relating to the blending site (partial flow treatment is required) and the site of occurrence. This can even extend to specific substances being banned, and/or the imposition of specific processing stages.

Corrosive substances

When evaluating which substances are corrosive (and in what concentrations), one not only has to look at the substances themselves, but also the choice of materials in particular.

Types of corrosion with cement-bound materials

In the case of cement-bound materials, a distinction is made between three kinds of corrosion: attack due to sulphate expansion; attack by acids; attack caused by exchange reactions in the crystal lattice, e. g. involving chloride, ammonium or magnesium. Good-quality concrete is able to offer sufficient resistance under long-term exposure if the following limits are not exceeded: SO_4 < 600 mg/l (< 3.000 mg/l for high sulphate-resistant concrete); inorganic and organic acids pH > 6.5; lime-dissolving carbonic acid < 15 mg/1; magnesium < 1.000 mg/l; ammonium nitrogen < 300 mg/l.

Corrosion of metals

Metal corrosion is an electrochemical process for which a conductive liquid such as water must be present. The main problem with metal materials is a high chloride content, which can lead to corrosion, even when high-grade steel is used. It is impossible to specify any concentration of chloride that is generally valid because the risk of corrosion depends on a multiplicity of parameters such as quality of materials, redox potential, gap width, flow velocity, temperature, quality of finish, etc.

Corrosion of plastics

Plastics are commonly regarded as being largely corrosion-proof. However, some plastics are not resistant to acids, alkalis, solvents or oils, so one has to consult resistance tables and check the manufacturer's advice when dealing with aggressive media.

Operating and auxiliary materials

Industrial enterprises use a multitude of cleaning agents, disinfectants, conveyor belt lubricants, dyestuffs, etc. In higher concentrations, many of these materials have an inhibiting or even toxic impact on biological purification methods. They may also contain components such as AOX which cannot be eliminated in the wastewater treatment plant.

The unimpeded maintenance of operations and production is the guiding principle for any industrial enterprise (for example, microbial contamination must on no account occur in food processing plants). Nonetheless, some examples tested in practice have shown that deliberately choosing appropriate measures, installing consumption-monitoring systems, or substituting particularly harmful substances can allow one to achieve efficient and cost-effective improvements in wastewater purification.

Specific pollutant loads

The specific pollutant loads can be ascertained from the pollutant concentrations, wastewater volumes and production volumes:

$$\text{spec. L} = \frac{Q_{WW} \cdot C}{P} \qquad \textbf{(2.3)}$$

where

spec. L	Specific pollutant load, e. g. [kg COD/kg]
Q_{WW}	Wastewater flow [m^3/d]
C	Wastewater concentration [kg/m^3]
P	Product unit, e. g. mass [kg/d]

The water and wastewater flows along with the pollutant loads constitute the basic data needed for further calculations, and enable comparisons with published values to be made.

2.2.2 Proposals for process-integrated procedures

Based upon the outcome of the status quo assessment, a second stage examines opportunities to adopt process-integrated measures:

Reorganising the production processes

Reorganising the production processes

- Reduce the amount of operating and auxiliary materials, cleaning agents and solvents (all sectors)
- Substitute biodegradable substances for non-degradable or persistent substances (all sectors)
- Replace oxidising agents that contain chlorine with H_2O_2 or ozone (for example, in the metalworking industry or textile finishing industry)
- Use dry cleaning processes (all sectors)

Optimising the production processes

Optimise the production processes

- Avoid product losses and losses of operating and auxiliary materials such as greases, oils, alkalis and acids via optimised production processes (all sectors)

Attainable corporate objectives

This allows one to achieve the following corporate objectives:

- Low raw material and energy consumption
- Higher product yield and improved product quality
- Reduced amounts of waste and wastewater to be disposed of

2.2.3 Proposals for production-integrated processes

Whereas changes to industrial production technologies can reduce water, wastewater and sludge loads, production-integrated measures involving the multiple re-use of water initially serve only to reduce the water and wastewater flows. Continual re-use of the water without any kind of intermediate treatment leads to increased concentrations.

The technologies used for resource recovery generally serve merely to reduce wastewater concentrations and/or pollutant loads. However, when the wastewater is treated and redeployed in the production process, this leads to a reduction both in wastewater volume and the concentration of substances contained in the wastewater. Production-integrated measures aimed at environmental protection are described below.

2.2.3.1 Production-integrated measures: multiple re-use of water

Where large quantities of water are used

Multiple re-use of water is often deployed when large quantities of water are used for cleaning and/or rinsing the products that are manufactured. Typical areas would be the metalworking and textile finishing industries.

Rinsing process without multiple re-use of water

Figure 2.6 illustrates a rinsing process without multiple re-use of water. In this case, the contaminated product is cleaned via so-called single-flow rinsing. This process must be repeated consecutively, depending on how clean the product needs to be. Such a procedure obviously consumes a high volume of water.

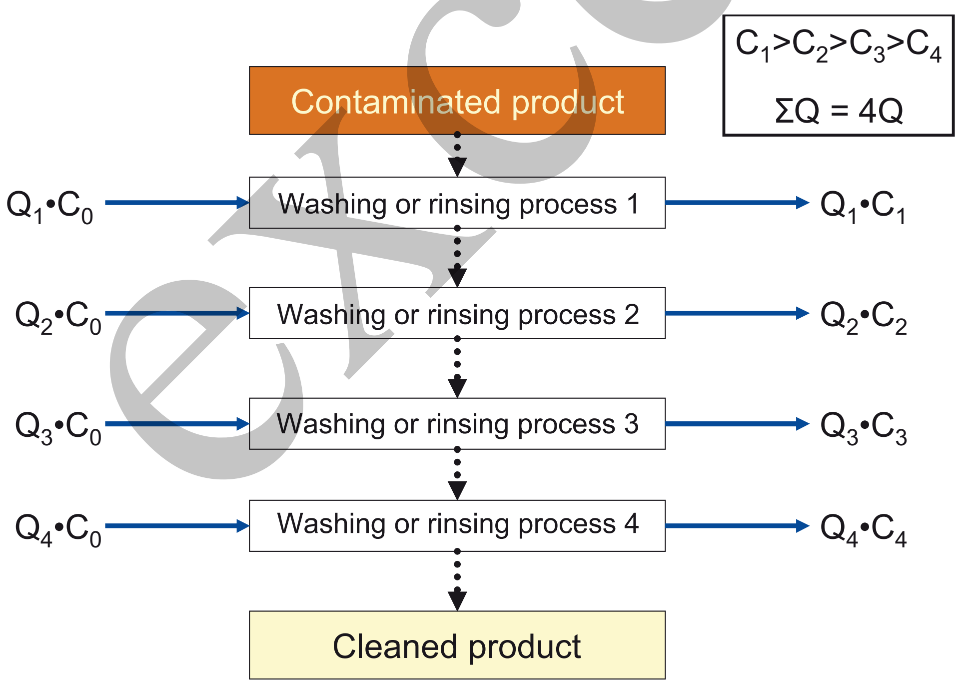

Fig. 2.6: Rinsing process without multiple re-use of water

Multiple re-use of rinsing water

By carrying out *multiple rinsing in stages* (see *Figure 2.7*) and *counterflow or cascade rinsing* (see *Figure 2.8*) it is possible to considerably reduce the volume of wastewater [8], [6]. The rinsing water flows through several rinsing basins in the opposite direction to the product flow so that the first rinse takes place in the most concentrated water and the last rinse in the cleanest water. In the example of a four-stage rinsing process given here, multi-stage multiple rinsing can halve the quantity of water needed and/or the amount of wastewater produced when compared to a system that does not re-use water, while the counterflow rinsing procedure can even reduce this volume to one quarter. However, the application of counterflow systems is limited in cases where the differences in concentration of the individual wastewaters produced in the sub-stages of a given process (C_1 and C_2, or C_2 and C_3, or C_3 and C_4) are very low.

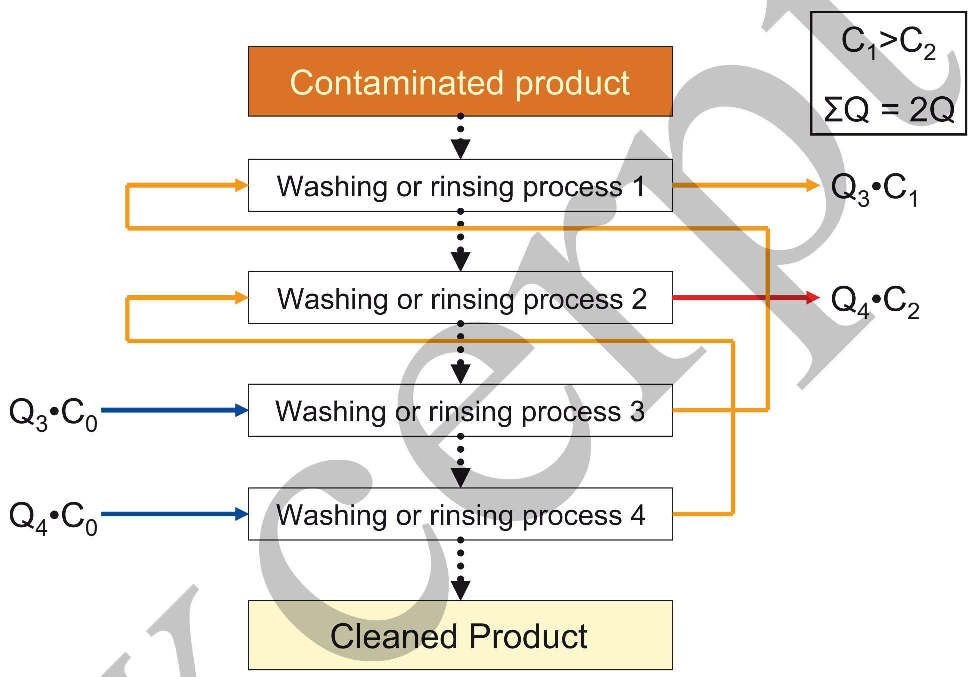

Fig. 2.7: Multiple rinsing in four stages

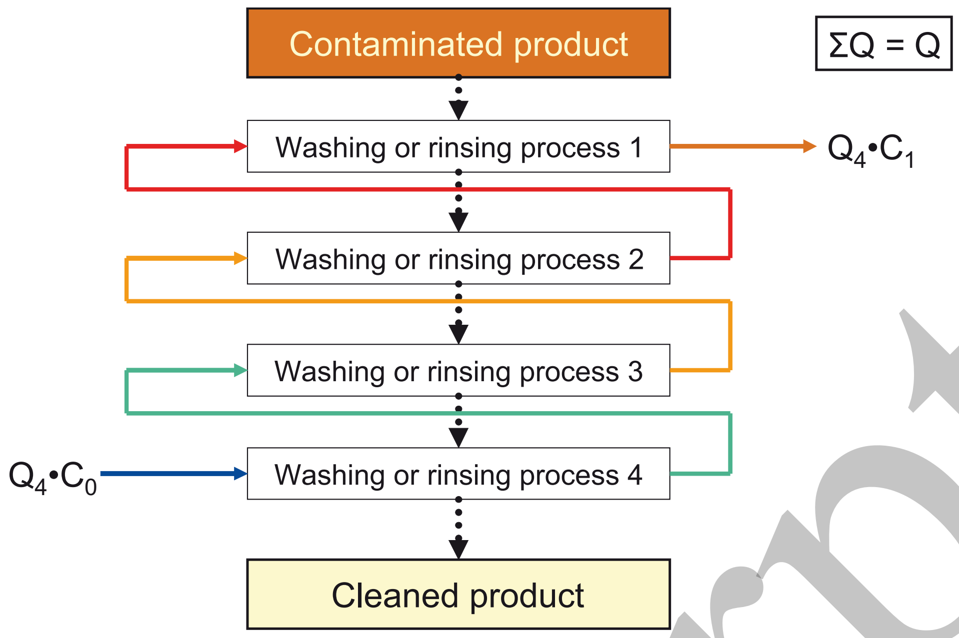

Fig. 2.8: **Cascade or counterflow rinsing**

2.2.3.2 Production-integrated measure: water recirculation

Accumulation of substances in the recirculation water and hence in the production water

When recirculating water, it is important to bear in mind that the emissions created during the process will lead to an accumulation of constituents in the recirculated water and thus the production water too. This may interfere with the production process or prevent the desired quality of product from being attained. This is why it is so important to know the permissible concentrations of service water constituents that can impact on production and products; both chemical and microbiological parameters can be of assistance here. In order to prevent an accumulation of this sort in the circulating water, a substance sink (i. e. treatment system) must be installed upstream of the point at which water is reintroduced into the process.

Completely closed recirculation is never possible

When it comes to substance elimination, treatment plants achieve levels of efficiency that are below 100 %; water may also be consumed and/or lost during production, so it is never possible to have completely closed circulation. For this reason, fresh water must continue to be added, either for dilution purposes or to compensate for water lost.

Figure 2.9 illustrates the principle of recirculation, giving the respective volume flows and concentrations.

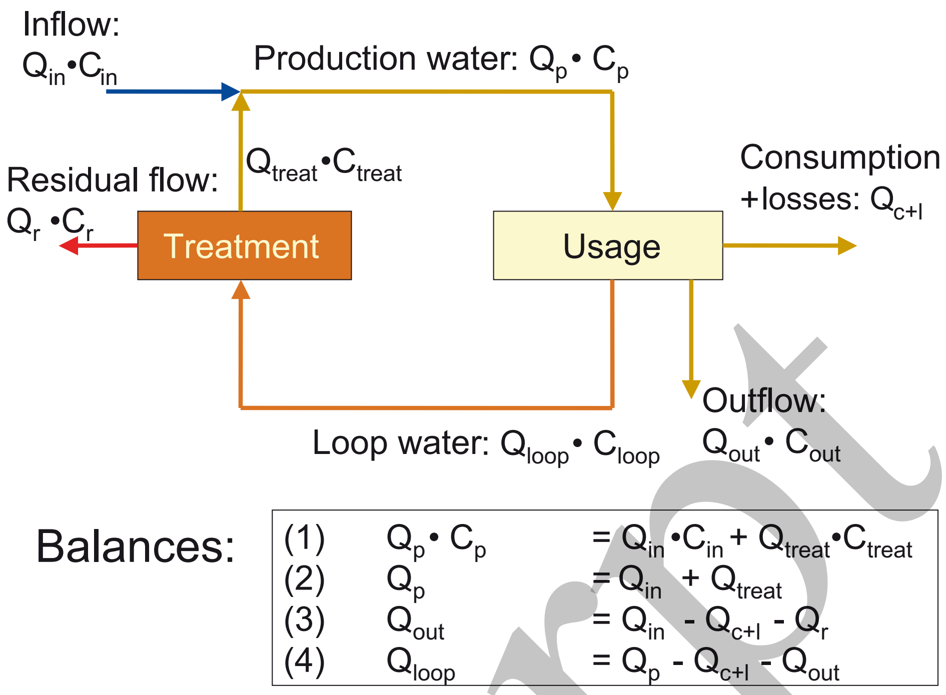

Fig. 2.9: Principle of water recirculation in production processes

Balance equations for service water and wastewater flows

From this it is possible to draw up the following balance equations for service water and wastewater flows:

$$Q_P \cdot C_P = Q_{in} \cdot C_{in} + Q_{treat} \cdot C_{treat} \quad \textbf{(2.4)}$$

where:

Q_P	Service water flow required for production [m³/h]
C_P	Concentration in service water required for production [mg/l]
Q_{in}	Volume flow of fresh water [m^3/h]
C_{in}	Concentration in fresh water [mg/l]
Q_{treat}	Volume flow in discharge from treatment plant [m^3/h]
C_{treat}	Concentration in discharge from treatment plant [mg/l]

$$Q_P = Q_{in} + Q_{treat} \quad \textbf{(2.5)}$$

$$Q_{out} = Q_{in} - Q_{c+1} - Q_r \tag{2.6}$$

where:

Q_{out}	Wastewater flow rate [m^3/h]
Q_{c+l}	Volume flow from consumption and losses during production [m^3/h]
Q_r	Residual volume flow from treatment plant (e. g. excess sludge concentrate) [m^3/h]

$$Q_{loop} = Q_p - Q_c + 1 - Q_{out} \tag{2.7}$$

where:

Q_{loop}	Volume flow in treatment plant intake [m^3/h]

Ascertaining the amount of freshwater to be added - possible recirculation

A typical task for planners is to ascertain the amount of fresh water to be added or the possibility of recirculation. As a rule, the particular type of production at a given enterprise dictates the volume flow (Q_p) and the quality of service water (C_p). The concentration of the freshwater (C_{in}) can be determined through analysis. If the treatment plant designer selects a process whereby they can guarantee a certain C_{treat} in the treatment plant's outlet, and if the treatment process chosen means that the residual volume flow from the treatment plant (Q_r) is negligible, the equations outlined above can be used to calculate the requisite fresh water volume flow (Q_{in}) and the volume flow in the treatment plant's outlet (Q_{treat}).

Formula 2.4 and *Formula 2.5* yield the following:

$$Q_{treat} = Q_{in} \cdot \frac{C_{in} - C_p}{C_p - C_{treat}} \tag{2.8}$$

The fresh water volume is calculated thus:

$$Q_{in} = \frac{Q_P}{1 + \frac{C_{in} - C_p}{C_p - C_{treat}}} \tag{2.9}$$

Wastewater volume flow

The wastewater volume flow Q_{out} depends on losses incurred during production and via evaporation. The following cases may arise:

Case 1: $Q_{in} = Q_{c+l} \rightarrow Q_{out} = 0$

$\rightarrow$ wastewater-free operation

Case 2: $Q_{c+l} < Q_{in} \rightarrow Q_{out} > 0$

$\rightarrow$ wastewater accumulation

Maximum amount of water deployable for recirculation

The maximum amount of water deployable for recirculation is determined by consumption and losses. Satisfactory service water quality must be achieved via treatment.

Sample calculation 2.2 **(recirculation of water):**

A factory uses 60 m^3/h production water to manufacture a product. Water consumption and loss during manufacture amount to 40 m^3/h; the intention is to prevent any accumulation of wastewater. The concentration of Substance XY should not exceed 10 mg/l for the production process; it can be reduced to 20 mg/l after treatment. The following conditions also apply:

- As a result of the procedure chosen, the residual volume flow from the treatment plant is negligible.
- Substance XY is completely dissolved, and no conversion processes (apart from treatment) occur.

One needs to calculate the amount of fresh water to be added and the concentration of substances in the fresh water that must be adhered to.

Steps toward a solution:

- $Q_p \cdot C_p = Q_{in} \cdot C_{in} + Q_{treat} \cdot C_{treat}$
- Calculation of quantities of water:

  $Q_{treat} = Q_p - Q_{c+l} - Q_{out} \; (- Q_r)$

  $= 60\ m^3/h - 40\ m^3/h - 0 = 20\ m^3/h$

  $Q_{in} = Q_p - Q_{treat} = 60\ m^3/h - 20\ m^3/h = \underline{40\ m^3/h}$

- $60\ m^3/h \cdot 10\ mg/l = 40\ m^3/h \cdot C_{in} + 20\ m^3/h \cdot 20\ mg/l$

  $C_{in} \leq \underline{5\ mg/l}$

2.2.3.3 Production-integrated measure: substance recovery technologies

As well as being used for wastewater treatment, multiple re-use and recirculation procedures can also be deployed for cooling water, cleaning alkalis and acids (e. g. food and drink industry), solvents (e. g. metalworking and textile finishing industries), industrial chemicals, or other auxiliary materials. It is normal in such cases for the relevant chemicals to be at least partially released from the water (i. e. they need to be concentrated and/or purified), so the process is known as material recovery.

Possible uses

For example, substance recovery technologies are used to recover:

- Sizing agents (textile finishing industry)
- Paint (automobile industry)
- Chromium (leather industry)
- Oil (various industries)

- Protein and pectin (food industry)
- Feedstuffs (brewer's grain, grape marc and pomace from the drinks industry)

2.2.4 Pre-treatment and treatment of wastewater

There are a variety of objectives when treating a wastewater flow. For example:

- Multiple re-use
- Recirculation
- Substance recovery
- Pre-treatment
- Direct discharge
- Indirect charge

  Once the relevant objective has been chosen, and the required wastewater composition has been identified, the actual treatment process can be selected.

A selection of possible procedural components is summarised in *Table 2.3*.

Selection of possible procedural components

Table 2.3: Procedures for wastewater treatment

Pre-treatment	Balancing volumes
	Balancing concentrations
	Neutralisation
Substance separation, mechanical / physical	Screen, sieve
	Sedimentation
	Centrifugation
	Separation of floating matter
	Flotation
	Filtration
Substance separation, chemical / physical	Adsorption
	Precipitation / flocculation
	Concentration / evaporation
	Ion exchange
	Extraction
	Stripping
Biological metabolism	aerobic - anaerobic
	suspended – attached to carrier
Chemical metabolism	Oxidation, photooxidation
	Reduction
Electrochemical metabolism	Electrolysis

2.2.5 Comparison of economic viability

A comparison of economic viability is crucial to the development of an economically optimal wastewater concept which is geared to a specific enterprise. Above all, it helps in choosing a single process or several alternative processes, or may facilitate a general efficiency audit.

Pre-selection criteria

A qualitative pre-selection of several available processes in the field of wastewater treatment can be based on the following criteria:

- Any pre-treatment stages that must precede the main treatment stage
- Investment needed
- Residue volumes
- Energy needed
- Chemicals needed
- Space needed
- References to experiences with similar wastewater
- Process reliability

Capital budgeting

The viability of measures based purely on economic efficiency is assessed with the help of **capital budgeting**:

- Static cost comparison
- Dynamic cost comparison
- Visualization of Financial Implications (VOFI) method
- Cost-benefit analyses

Cost-benefit analysis

A useful tool in capital budgeting is the cost-benefit analysis, which looks at a measure's overall efficiency. On the cost side, one identifies the investment, operating costs and overall annual costs associated with a procedure; in return, one identifies the benefits such as savings in charges for water, wastewater, and wastewater levies. One might also calculate the benefit derived from energy recovery and the revenue from any resource recovery.

The analysis is expressed in monetary units

The analysis itself is expressed in monetary units; the value judgements are ultimately summarised in the form of a single metric (e. g. capitalised cost savings). Verbal arguments dealing with the effects not accounted for in the analytical calculation are then prepared for the decision-making process. For example, they include evaluation criteria such as the future waste disposal situation or in-house knowledge relating to the measures under investigation.

Furthermore, the possible impacts on a municipal sewage plant need to be considered within the scope of an overall concept.

VDI Guideline 3800 [12] contains instructions for determining expenditure on industrial environmental protection. *Figure 2.10* gives an overview of this expenditure.

Expenditure on industrial environmental protection

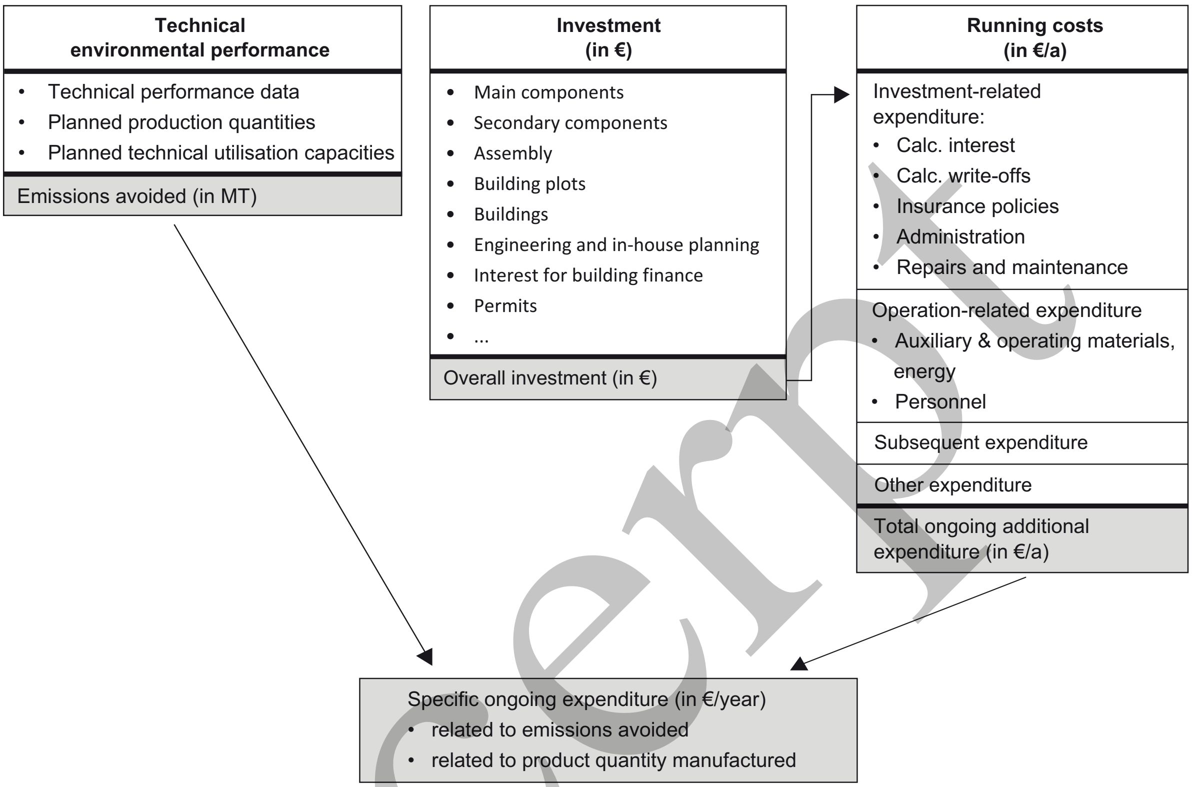

Fig. 2.10: Overview of expenditure on industrial environmental protection measures [12]

Expenditure on environmental protection is summarised in the following formula, in line with VDI Guideline 3800 (2001):

Overall annual expenditure

$$T = \sum_j \underbrace{e_j(I + \Delta I_j)}_{a)^*} + \sum_i \underbrace{q_i p_i}_{b)^*} + E \cdot p + O + S - R \qquad \textbf{(2.10)}$$

* a) Investment-related expenditure, b) Operational expenditure

where:

T	Aggregate annual turnover [€/a]
I	Investment [€]
e_j	Percentage rate for ascertaining investment-related expenditure j in [%] or [I/a]
ΔI_j	Additions to and/or deductions from investment I when determining the type of expenditure (j) (e. g. cutting back on investment when determining amortisation / depreciation) [€]
q_i	Technical consumption rate for component i [quantity unit/a]
p_i	Transfer price associated with consumption rate i [€/quantity unit]
E	Personnel requirements [number of employees]
p	Personnel expenditure [€/(a·employees)]
O	Other expenditure [€/a]
S	Subsequent expenditure [€/a]
R	Possible revenue from sales, adoption of secondary raw materials [€/a]

Low operating costs are a priority

The tendency in the industrial sector is to favour processes that manifest high investment in return for low operating costs. At the same time, it is generally recognised that any such investment must have paid for itself within 5 years at the latest (return on investment).

For further reading on capital budgeting, see [7].

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2.A Index

Glossary

A

abiotic factors

1 Physical, chemical and hydrographic milieu factors; parameters of the inanimate environment.

2 Chemical and physical (inanimate) factors that act upon a living being.

acid capacity

1 Acid capacity is the quantitative capability of an aqueous medium to react with hydronium ions. The analysis mainly detects the concentration of hydrogen carbonate, carbonate and hydroxide. Other buffer substances such as ammonia, borate, phosphate, silicates, humic acids and other organic anions may be detected by this analysis (DIN 38409 H7).

2 The measurement of acid capacity is a yardstick for the water's ability to buffer acids, and is thus responsible for the stability of its pH value.

activated carbon

Also known as activated charcoal, this is highly porous pure carbon with a large surface area (between 300 and 1100 m^2/g). It is obtained by coking wood, peat, brown coal, black coal, etc., followed by activation with water vapour. The micropores that are vital for adsorption are produced by partial burning off at 700 to 1000 °C.

activated sludge

Sludge comprising unicellular and multicellular microbes (e. g. bacteria, fungi) inside the aeration tank of a wastewater plant. The growth of activated sludge in the aeration tank results from the vital activity of the microorganisms. The microbes present in activated sludge degrade the organic substances contained in the wastewater by using oxygen for their metabolism.

activated sludge floc

A sludge floc developing during the activated sludge process. See: DIN 4045.

activated sludge process

1 A biological wastewater purification process. As a result of extensive circulation and aeration (oxygen input) in a tank, the metabolism of the microorganisms causes the formation of mucilaginous bacteria-containing flocs in which biological self-purification occurs; the flocs settle in the settling tank.

2 A biological wastewater purification process whereby a mixture of wastewater and activated sludge is aerated and stirred. The activated sludge is then separated from the purified wastewater in a final sedimentation tank and returned to the aeration tank as return activated sludge. Part of the activated sludge is removed as excess sludge.

Source: DIN EN 1085

3 Biological wastewater purification processes intensify and optimise the degradation mechanisms that occur in nature. During the activated sludge process, aerobic degradation of the organic substances contained in wastewater occurs as a result of microorganisms held in suspension. (See also: biofilm process)

adsorption

(*ad* Lat. = to; *adsorbere* Lat. = to adsorb). The attachment of gases or dissolved substances to the surface of solids (adsorbents, adsorption media) in an adsorber. Adsorption removes pollutants from waste gases or liquids.

aerated wastewater lagoon

A wastewater lagoon with artificial aeration and no sludge recirculation.

Source: DIN EN 1085

aeration

1 Aeration generally means the exchange of gases between water and air in order to introduce oxygen and possibly remove dissolved gases (DIN 4046).

2 Enrichment of water or a water body with air or pure oxygen. Aeration processes are used in wastewater plants, when treating drinking water (for example, to remove dissolved iron or manganese), and to support the self-purification properties of water bodies.

3 Wastewater treatment: artificial introduction of air into wastewater in order to promote the oxidation of inorganic compounds (Fe^{2+} to Fe^{3+}), to provide a sufficient supply of oxygen in biological wastewater purification, and for stripping volatile substances.

Water can, for example, be aerated with the help of cascades. The aeration of wastewater occurs in so-called aeration tanks as a result of introducing oxygen via air or oxygen gas.

A distinction is made between:

- Surface aeration
- Compressed air aeration
- Jet aeration
- Simplex or impeller aeration
- Drum aeration

- Oxygenation

aeration plant

1 A biological wastewater purification plant. The bacteria and microbes that degrade the pollutants form free-floating flocs in the water. Circulation and aeration are used in these plants in a very small space to keep large quantities of activated sludge afloat and supply it with oxygen, which achieves rapid wastewater purification via adsorption to the activated sludge floc, and to some extent via biochemical degradation too.

2 A biological wastewater purification plant with activated sludge, comprising an aeration tank and final sedimentation tank.

Source: Lexikon der Abwassertechnik, 7th Edition

aeration tank

A structure intended for the activated sludge process in which activated sludge is kept afloat; oxygen is taken up, and organic substances are degraded and converted into activated sludge.

aerobic

1 (*aer* Gk. = air; *bios* Gk. = life). In general: needing or containing oxygen (with reference to organisms, chemical reactions).

2 A term that describes the lifestyle of organisms which need oxygen to breathe, or types of chemical reaction that are only possible if oxygen is present (aerobic respiration).

3 The status of a biocoenosis whose (watery) environment contains dissolved oxygen. (See also: anaerobic, anoxic).

Source: Lexikon der Abwassertechnik, 7th Edition

aerobic degradation

1 Degradation processes in which oxygen is consumed.

2 Degradation via microorganisms during which oxygen is consumed (Source: DIN 4045). This refers to the principle favoured by municipal and industrial wastewater plants. A variety of aeration aggregates provide the oxygenation capacity (See also: aerobic).

aerobic wastewater purification

Purification of wastewater with the aid of aerobic organisms in the presence of added oxygen.

Source: Lexikon der Abwassertechnik, 7th Edition

adsorption isotherm

The adsorption isotherm describes the amount of adsorbate (i. e. a substance that has been or is to be adsorbed) on the adsorbent (i. e. a material on which adsorption can occur) as a function of its pressure (if gas) or concentration (if liquid) at constant temperature.

advanced wastewater purification

(3rd purification stage) Wastewater purification processes that are deployed in addition to the mechanical and biological purification stages which are normally used today, and which aim to remove further pollutants from wastewater.

agricultural wastewater

Wastewater from agricultural businesses.

alkalinity

The ability of a substance to neutralise acids as a result of its bicarbonate, carbonate or hydroxide content. The process is usually expressed in milligrams per litre calcium carbonate equivalent. (See also: acid capacity)

alternating

Occurring alternately with something else.

ammonification

The conversion of compounds containing organic nitrogen into ammonium ions.

Source: DIN EN 1085

anaerobic

1 (*aneu* Gk. = without; *aer* Gk. = air); a term that describes the lack of molecular oxygen.

2 The status of a biocoenosis whose (watery) environment contains neither dissolved nor chemically bonded oxygen (e. g. in the form of nitrate, nitrite or sulphate). See also: aerobic, anoxic

Source: Lexikon der Abwassertechnik, 7th Edition

anaerobic degradation

1 Degradation processes in which no oxygen is consumed.

2 Degradation of substances by microorganisms under anaerobic conditions. In wastewater technology this might, for example, refer to digestion leading to the stabilisation of sewage sludge (See: sewage sludge stabilisation).

anaerobic wastewater purification

Purification of wastewater with the aid of anaerobic organisms in the absence of oxygen.

Source: DIN 4045

anaerobically digested sludge

1 Sludge that is stabilised as a result of anaerobic digestion.

Source: DIN EN 1085

2 Sludge that is produced by degradation processes in water bodies or sludge that is anaerobically treated in wastewater plants (sewage sludge); amongst other things, it releases hydrogen sulphide, ammonia, carbon dioxide and methane.

3 Fine-grained, grey to jet-black sediment in water bodies which is produced with the exclusion of oxygen from biochemically transformed plant and animal residues. It contains a high percentage of semi-decomposed organic substances, plus calcium carbonate, iron sulphide and pyrite. The formation of free hydrogen sulphide (H_2S) produces a foul smell. Digested sludge is seen as the preliminary stage to the formation of mineral oil.

anion

A negatively charged ion.

anoxic

The status of a biocoenosis whose (watery) environment contains no dissolved oxygen, but chemically bonded oxygen instead (e. g. in the form of nitrate, nitrite or sulphate). See also: aerobic, anaerobic

Source: Lexikon der Abwassertechnik, 7th Edition

anthropogenic

Caused or produced by human beings.

ATP

Compounds of the amino acid adenosine with phosphates, adenosine triphosphate (ATP) and adenosine diphosphate (ADP) serve to transfer energy in the metabolism of microorganisms.

authorisation

In an administrative act, the permit to carry out a legal act or deed.

autotrophic

1 (*autos* Gk. = self; *trophe* Gk. = nutrition); feeding solely on inorganic substances.

2 A term that describes the type of nourishment used by organisms that only require inorganic materials (water, carbon dioxide, salts, nitrogen compounds) to build up their bodily substance. They include all green plants, algae and some bacteria. (See also: heterotrophic).

B

bacteria

1 Unicellular microorganisms which reproduce by dividing, and which play an important role in biological degradation processes (biological degradation, putrefaction, decay, fermentation, etc.) as well as acting as pathogens.

A distinction (according to lifestyle) is made between:

- Fastidious aerobic bacteria (aerobes, need aerobic conditions only)
- Fastidious anaerobic bacteria (anaerobes, need anaerobic conditions only)
- Facultative aerobic and anaerobic bacteria (can live under aerobic as well as anaerobic conditions)

A distinction (according to ambient temperature) is made between:

- Psychrophilic bacteria (optimum temperature < 20 °C)
- Mesophilic bacteria (optimum temperature 20-45 °C)
- Thermophilic bacteria (optimum temperature > 45 °C)

2 Unicellular, microscopically small organisms whose form is spherical, rod-shaped, or curved. Heterotrophic bacteria are able to degrade organic compounds, so they play an important role in the self-purification of water bodies, the degradation of organic substances in the water bottom (bank filtration) or in the top layer of a slow sand filter, and in biological wastewater purification in wastewater plants.

Batch reactor

The Batch reactor has a constant volume. It has neither an inflow nor an outflow, and is thus a closed system (except when exchanging gases). Test tubes in a laboratory are typical Batch reactors.

best available techniques

Also referred to as Best Available Technology (BAT). EU Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control defines BAT as follows:

'…the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole'.

In German environmental legislation, BAT is often equated with 'state of the art'.

biocatalyst

A substance which (in very small quantities) influences the biochemical reactions of living beings: enzymes, vitamins, growth promoters, hormones.

Biochemical Oxygen Demand

1 (BOD) A standard test in water treatment in order to establish the level of organic pollution. It refers to the amount of dissolved oxygen required for the aerobic degradation by a corresponding microbiocoenosis (at 20 °C) of the biochemically oxidisable constituents in a litre of sample water in *n* days. In biological wastewater purification, the BOD is generally measured in five days in order to assess the installation.

2 A measure of the quantity of dissolved oxygen required for the biological degradation of organic substances in wastewater. The figure used is normally BOD_5, which indicates the quantity of oxygen in mg/l that bacteria and other tiny microbes in a water sample need over five days at 20 °C for biological degradation.

biocoenosis

1 (*bios* Gk. = life; *koinos* Gk. = common); a community of animals and plants in a biotope.

2 A community of different types of organisms, determined by environmental conditions and their relationship to one another.

Source: DIN 4049 Sheet 2

biofilm process

A biological wastewater purification process whereby the degradation of the organic wastewater constituents is achieved via microorganisms growing on surfaces (substrata). The growth of the microorganisms on the substratum is called biofilm. Degradation is aerobic.

For example, biofilm processes include trickling filters, submerged rotating trickling filters, submerged fixed bed reactors, or planted soil filters.

biological contactor

A biofilm reactor with support media that are constantly or periodically immersed in the wastewater, sometimes combined with a supply of air. It is also referred to as a submerged trickling filter.

biological wastewater purification

1 In biological wastewater purification, the organic constituents in wastewater are subjected to a degradation process. Degradation is achieved via microorganisms such as bacteria and fungi in conjunction with oxygen. When this happens, conversion processes lead to the formation of inorganic compounds (e. g. carbon dioxide or water) and a constant biomass. The latter sinks to the bottom in the final sedimentation tank where it is removed from the water as return activated sludge / excess sludge and then reprocessed. This process occurs without interruption so long as the microbes are protected from acids, leaches and toxins, and the wastewater provides them with a steady supply of fresh nutrients and sufficient oxygen. In adequately monitored and carefully operated mechanical / biological wastewater plants, wastewater can be purified to such an extent that fish can live in it. Nevertheless, state-of-the-art wastewater plants only remove around 90 % of the dirt, pollutants and pathogens from the wastewater. In cases where the residual pollution from urban or industrial wastewater is still too high and/or it exceeds the self-purification capacity of the receiving water, advanced wastewater purification (tertiary purification stage) is required.

2 Degradation of dissolved organic substances by anaerobic or aerobic microorganisms in activated sludge systems (e. g. ponds, tall bioreactors) or on so-called biofilm in trickling filters. This happens in wastewater plants as a result of technically intensified biological self-purification (e. g. support medium, surface aerator). See also: activated sludge process.

broad irrigation

1 The artificial sprinkling of wastewater onto areas of land in order to purify the wastewater via percolation, whereby the layers of soil act as a filter.

Source: Lexikon der Abwassertechnik, 7th Edition

2 Agricultural utilisation of wastewater. Also known as land treatment, the clarified wastewater is sprayed using an irrigation system (see also: wastewater disposal).

C

cadmium

1 Cadmium (Cd) is one of the 'hazardous substances' in sewage sludge.

2 A silvery-white, shiny metal. Metallic cadmium is used in the manufacture of batteries (nickel-cadmium batteries) and to produce protective galvanic coatings on metal parts. The majority of this metal is used in the form of cadmium compounds, as colour pigments and as a stabiliser in the manufacture of plastics (PVC). Cadmium accumulates via the food chain in aquatic organisms and, when eaten, in the human body too. 6 % of the cadmium ingested is actually taken up into the human body, and is only partially excreted (accumulation). Long-term

exposure to cadmium can lead to kidney damage and, under certain conditions, to changes to the bones (itai-itai disease).

3 Higher concentrations of cadmium inhibit the growth of aquatic organisms. Cadmium salts are extremely damaging to water bodies, and even very small quantities will poison the environment. The Wastewater Charges Act states that the discharge of cadmium is subject to a levy. As specified by Annex X of the Water Framework Directive, cadmium and its compounds are included among the priority hazardous substances.

cation

Cations are ions that migrate to the cathode during electrolysis, i. e. positively charged ions such as H^+.

centrifuge

A device for the dewatering of sludge where the sludge water and solids are separated off under the influence of centrifugal force.

chamber filter press

A machine used for the artificial dewatering of sewage sludge.

Filter plates are used to form a chamber, with a filter cloth mounted over each of the two faces of the filter plate. The chamber is then filled with sludge and placed under pressure. The sludge water is squeezed out and discharged as filtrate via drainage channels within the plates. Once the plates have been opened by pushing them apart, the dewatered sludge falls out in the form of filter cake. Generally speaking, the most advanced artificial dewatering can be achieved by using filter presses, and the filtrate is free of solids.

Source: Lexikon der Abwassertechnik, 7^{th} Edition

chelating agents

Chelating agents (also known as complexing agents) is the generic term for compounds that enter into complex compounds with specific central atoms. In the narrower sense, chelating agents are defined as substances that lead to chelate complexes. Important chelating agents include certain phosphates, phosphonates and ethylenediaminetetraacetic acid (abbreviated to EDTA) and nitrilotriacetic acid (abbreviated to NTA). Numerous chelate complexes manifest such major stability that the element of the central atom can no longer be chemically verified. This effect, which is also described as masking, has a variety of applications: in analytical chemistry, it removes disruptive elements from the solution, and in the case of detergents the chelating agents bond the calcium ions so that no limescale deposits can precipitate on the laundry or washing machine parts. Moreover, the intense colouring of some chelate complexes is used during the manufacture of dyestuffs.

Source: Microsoft® Encarta® Online-Enzyklopädie 2009

Chemical Oxygen Demand

1 (COD) The quantity of dissolved oxygen in mg/l or g/m^3 that is required for the complete oxidation of the organic substances contained in water. Potassium dichromate ($K_2Cr_2O_7$) is normally used as a chemical oxidising agent (DIN 38409-H41, Dec. 1980 Edition).

2 In the case of domestic wastewater, the COD is approximately twice the BOD_5 (Biochemical Oxygen Demand) of the same water sample under investigation. Higher COD ratios indicate the presence of persistent organic substances in the wastewater. The COD also serves to establish levies charged in accordance with the Wastewater Charges Act.

3 A measure of the sum of all organic substances in water (and particularly wastewater), including persistent organic substances. The COD indicates how much oxygen is required for the complete oxidation of the organic substances by chemicals.

chromatography

A physical and physical / chemical separation and verification procedure for the qualitative and quantitative chemical analysis of substances derived from a mixture of substances.

chromium

1 Chromium (Cr) is a relatively common element, and occurs in the earth's crust in an average concentration of 200 mg/kg. One generally finds 10 to 90 mg/kg in soils.

2 Trivalent chromium is an essential trace element for humans and animals. Hexavalent chromium compounds cause allergic and asthmatic reactions, and are considered to be carcinogenic.

3 Chromium is, amongst other things, used in the electroplating industry to finish metal surfaces. It is likewise used in metal alloys, in colour pigments, as a catalyst, for the impregnation of wood, and as a tanning agent in leather processing.

4 Chromium and chromium compounds mainly find their way into surface waters via the wastewater of the chromium processing industry, electroplating businesses, and tanneries. Chromium occurs in water bodies in trivalent or hexavalent form. Chromium(VI) is stable under aerobic conditions, while under anaerobic conditions it is broken down into Chromium(III). Under oxidising conditions, a conversion of Chromium(III) into Chromium(VI) is

also possible. Determined by the formation of (not readily soluble) Chromium(III) compounds and the adsorption of chromium to suspended matter, a large part of the chromium is bonded to particles.

coagulants

Substances that are added in order to precipitate dissolved or very finely distributed substances.

coagulation

Coagulation refers to the destabilisation of finely dispersed or colloidal systems whose homogeneous load is in suspension at the surface. As a result of the homogeneous load, the particles are unable to converge and combine to form larger flocs. The introduction of flocculants such as iron or aluminium salts adds oppositely charged ions (anti-colloids) which compensate for the loading of colloids and thus enable clusters of flocs to form.

coastal waters

1 Water bodies between, on the one hand, the shoreline of the mainland coast or the seaward delineation of surface waters and, on the other hand, the outer limit of territorial waters (where territorial waters meet the high seas).

2 Surface water bodies on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters.

compressibility

A measure of the change in the specific filtration resistance of a sludge, depending on the pressure exerted.

Source: Lexikon der Abwassertechnik, 7^{th} Edition

commercial wastewater

Wastewater from commercial premises. (See also: industrial wastewater)

Source: DIN EN 1085

compressed air aeration

A process whereby air is blown under pressure into the aeration tank through pipes, filter candles, membrane aerators or similar. Oxygen is transferred via the air bubbles that rise up. Depending on the size of the bubbles, a distinction is made between fine, medium and coarse bubble aeration.

Source: Lexikon der Abwassertechnik, 7^{th} Edition

constructed wetland

1 A semi-natural wastewater plant with vertical or horizontal throughflow comprising a bed made of sand or gravel material and covered with marsh plants. The planting usually consists of reeds, but can also include bulrushes, sedges, and irises. Depth of bed > 0.6 m, associated surface area = 4–5 m^2 per inhabitant (DWA Worksheet A 262). Low operating costs, but the space required means this is generally suitable for connection values < 1000 inhabitants.

Source: Lexikon der Abwassertechnik, 7^{th} Edition

2 In addition to the planted soil filter or the plant bed with surface throughflow, a constructed wetland comprises all the necessary peripheral facilities, including primary settlement.

consumer

1 An organism that consumes nutrients built up by the producer, differentiated into primary, secondary, and often tertiary consumers too.

2 (*consumere* Lat. = to consume); a heterotrophic organism that feeds on other organisms or parts thereof.

continuity equation

The continuity equation describes the behaviour of density in a volume element. What it principally states is that the source of a flow of objects equals the temporal change in its density.

cyclone

A device used to purify gas or remove the dust from a stream of waste gas, comprising a vertical cylinder into which gas or air is fed tangentially so that a vortex is produced. The coarse and fine dust particles are subjected to centrifugal force and are carried downward while the air escapes upward. Synonym: cyclone dust collector.

D

decanter

The purpose of decanters, which are also known as screw-type solid bowl centrifuges, is to thicken excess and digested sludge as part of the wastewater treatment process. They function according to the principle of pipe centrifuges, but unlike them have a scroll which rotates at a low differential rotation frequency to the drum and at the same time constantly shears the separated solids from the drum and removes them from the separation zone. This avoids operational interruptions which occur when the drums of conventional pipe centrifuges have to be disassembled and cleaned. As a result of their design and construction, decanters are relatively slow centrifuges (cf= 3,000–4,000), so the screen cut is > 2 µm in the case of low flow rates. In the case of high flow rates (up to 140 m^3/h), flocculants are often added to the inflow in order to achieve adequate separation (overall degree of separation q = 0.95-0.98).

degradation

1 A physical, chemical or biochemical process by which wastewater or sludge components are broken down.

Source: DIN EN 1085

2 The breakdown of complex organic compounds into simple molecules or ions as a result of physical, chemical and/or biological processes.

Source: DIN ISO 11074, 2006 Version

3 Chemistry: the breakdown of organic compounds consisting of many atoms into simpler compounds as a result of biological influences (e. g. via enzymes or microorganisms), chemical influences (e. g. slow oxidation, incineration, transformation) or physical influences (e. g. UV radiation).

4 Biology: the decomposition of organic substances by microorganisms and small animals, biotically, in the presence (aerobic) or absence (anaerobic) of oxygen, or as a result of abiotic processes (e. g. hydrolysis, oxidation).

degradation rate

The time required for the degradation of substances; depending on the test procedure, it is expressed as *n* hours or *n* days. It can be ascertained via degradation experiments in laboratories, and is important for the design of wastewater plants.

Source: DIN 38412 Section 24

denitrification

The reduction of nitrate or nitrite by specific microorganisms (denitrificants) under anoxic conditions which leads to the formation of free oxygen and nitrogen.

desorption

1 In general: a reversible process; for example, it 'releases' polar substances from non-polar surfaces.

2 The discharge of adsorbed gases from water.

decomposer

1 Also known as a degrader or mineraliser: an organism that degrades organic substances to form inorganic compounds.

2 Organisms (bacteria) that break down (mineralise) dead organic substances and excretory products into simple chemical constituents.

detergents

Substances with surfactant properties. Detergents are used as laundry, washing up and cleaning agents, and as flotation and fire extinguishing agents. See also: tensides.

Source: Lexikon der Abwassertechnik, 7th Edition

detritus

1 (*detere* Lat. = to rub away); in general: dead organic material.

2 A decomposition product of plant and animal origin, e. g. dead plants, excrement, corpses. This organic material is usually swarming with microorganisms, esp. bacteria and fungi, which mineralise it and thus make it available again for primary production.

3 The entirety of dead organic substances in water bodies, in the form of floating matter and settling sediment.

decentralised wastewater treatment

Refers to local wastewater treatment that avoids larger mixtures of wastewater and long drainage systems.

The concept of decentralised wastewater purification is based on the fundamental notion that wastewater which accumulates should be purified at its place of origin. This mainly makes sense if the channelling of wastewater to a central (large-scale) wastewater plant via pressure pipelines, pumping stations, etc. is uneconomical when compared to constructing a decentralised wastewater purification plant.

density current

A current that arises in flowing water as a result of differing densities (e. g. caused by temperature, floating matter content, salinity, etc.). For example, this can occur in settling tanks.

Source: DIN 4045

diffusion

The molecular movement of substances through a medium along a concentration gradient.

digester gas

A gaseous mixture that is produced during anaerobic digestion, mainly comprising methane (CH_4) and carbon dioxide (CO_2).

Source: DIN EN 1085

digestion

Anaerobic degradation of organic substances by microorganisms.

dilution

The mixing of wastewater with surface water. The reduction in the concentration of chemical substances present in a liquid, e. g. the reduction in the concentration of pollutants in water bodies by passing through soil filters.

direct discharger

A commercial or industrial enterprise that discharges its wastewater directly into a water body via its own sewage system. This requires a permit issued in accordance with the Federal Water Resources Act. The opposite: businesses that initially discharge their wastewater into municipal sewage systems, and thus 'indirectly' into water bodies (See: indirect discharger).

dispersion

1 The dissolving of particles in a solvent.

2 The fine, non-molecular distribution of one substance in another. Dispersions are possible within the liquid aggregate state and between different aggregate states.

3 A disperse system in which the particles from the disperse phase, i. e. those of the finely distributed substance (dispersant) do not cohere, but are instead separated from one another via a layer of the dispersion medium. Molecular dispersion, i. e. the distribution via molecular dispersal of one substance in another, is a genuine solution.

4 A procedure in flow processes of groundwater in the subsoil where, as a result of inhomogeneities, there are differing distances per unit of time for individual particles and dissolved substances that are transported.

dissociation

(*dissociare* Lat. = to separate). The decomposition of molecules (mostly salts) into their simpler constituents (ions) (e. g. $NaCl \rightarrow Na^+ + Cl^-$)

dissolved oxygen

The oxygen that is freely available in water. The quantity of oxygen that is dissolved in a stream, river or lake is an indicator of the health status of the water and its ability to support a balanced water-based ecological system. The solubility of the oxygen in water is determined by pressure and temperature.

domestic wastewater

1 Wastewater from private households (i. e. kitchens, washrooms, sinks, bathrooms, toilets and similar facilities). It contains excrement and urine, bathing water, washing up and laundry residues, food leftovers, plus any other liquid and sludgy waste introduced into domestic drainage (toilet, sink). The quantity per inhabitant roughly corresponds to the water usage per inhabitant, and as a consequence primarily depends on the standard of living: it amounts to between 80 and 400 litres a day. Domestic wastewater is part of municipal wastewater.

2 Environmentally damaging waste such as solvents, paint, fuels, pesticides, pharmaceutical products, but also cigarette butts, metals, plastics, etc. must not be added to domestic wastewater.

Source: DIN EN 1085

Dortmund tank

A funnel-shaped settling tank with mainly vertical throughflow, and usually central wastewater delivery; it is also sometimes referred to as a *Kniebühler tank*.

Source: DIN EN 1085

drinking water

1 Water that is suitable for human consumption, and which must fulfil specific quality criteria established in legislation and other legally binding standards. Drinking water is the most important foodstuff, for which there is no substitute. The basic requirements of clean drinking water are: free of pathogens; no properties that are harmful to health; low numbers of bacteria; appetising; colourless; chilled; odourless; irreproachable from a taste perspective; low content of dissolved substances (DIN 2000). Furthermore, drinking water must not cause excessive corrosion damage in the network of pipes and should be available at all times in sufficient quantity and at adequate pressure.

2 The origin of drinking water in the Federal Republic of Germany:

- Genuine groundwater and spring water: 71 %
- Enriched groundwater: 12 %
- Water accumulated and stored in reservoirs: 7 %
- Bank filtrate: 6 %
- Seawater: 3 %
- River water: 1 %

drum screen

A cylindrical wastewater screen whose diameter is very large in relation to its length. It turns slowly around a horizontal axis, and its lower section is immersed in water.

Source: Lexikon der Abwassertechnik, 7th Edition

dry residue

The percentage of the total mass of a sludge that consists of dry mass; this refers to a specific parameter. Dimension: kg/kg (DIN 4045). Unlike the dry mass content, the dry mass in this case refers to a specific weight. (DIN 4045).

dry substance

Substances after the removal of water by drying at 105 °C, until the weight is constant. See also: dry weight.

E

ecosystem

1 Encompasses a habitat that can be spatially delineated (e. g. a river basin or wetland) and the community living within it (e. g. plants, animals).

2 The animate and inanimate components of an ecosystem are linked to one another via mutual interrelationships. Ecosystems possess a certain ability to regulate themselves (e. g. the self-purification capacity of water bodies); if this fails, the overall character of the ecosystem can be altered, or parts or the totality thereof can be destroyed (e. g. eutrophication).

3 The mutually interacting system of a community of plants, animals and microbes with their non-organic environment. An ecosystem is a concrete unit with a fixed structure and function.

4 The functional unit of a biocoenosis and biotope, characterised by material, energy-related and information-related relationships and feedback, both amongst organisms as well as between organisms and their environment.

5 A functional unit of varying magnitude in which the organisms and their communities exist in a mutual natural relationship with every factor of their inanimate environment; the totality of inanimate bodies that interact with one another.

emission

1 (Lat. *emittere* = to send out, emit); the airborne pollution, soil and water pollution, noise, vibrations, heat, radiation and similar phenomena emanating from a source (emitter). Emissions as defined by the Federal Immission Control Act are the airborne pollution, soil and water pollution, noise, vibrations, heat, radiation and similar phenomena emanating from a given plant / facility.

2 Substances released into the atmosphere are described as emissions. Greenhouse gas emissions are usually indicated as an emission rate in tonnes/year. Emissions can originate from natural sources (volcanic eruptions, oceans, storms, etc.) or anthropogenic sources (caused by human beings). Emissions from anthropogenic sources are held responsible for the additional greenhouse effect.

endocrine substance

Chemicals that affect the hormonal system of humans and animals. Some examples of endocrine effects are:

- Altered hormone concentrations
- Altered activity (or ability to be stimulated) of endocrine glands (pineal gland, pituitary gland, pancreas, thyroid gland, adrenal cortex and medulla, gonads)
- The triggering or inhibition of hormone-specific effects

Substances where endocrine effects only appear as the secondary or unspecific consequence of other toxic effects and/or only in conjunction with other toxic effects that are not hormonally caused are not categorised as having an endocrine effect.

endogenous respiration

A situation in which living organisms oxidise some of their own cellular mass instead of new organic matter they adsorb or absorb from their environment.

Environmental Impact Assessment

The Environmental Impact Assessment is a dependent part of administrative procedures which serve to make decisions about the admissibility of specific projects. The Environmental Impact Assessment comprises the identification, description and assessment of the impact of a given project on:

- Humans, animals and plants, the soil, water, air, climate and countryside, including possible interactions
- Cultural assets and other real assets

Specific projects are subject to an Environmental Impact Assessment; they are listed in an Appendix to the relevant Act.

environmental protection

Protection of the environment from indefensible damage caused by the effects and operational procedures of products, processes and services (DIN EN 45020).

enzymes

1 A catalytic organic compound formed from living cells which controls the metabolism of the organism.

2 Ferments, proteins in the organism that are involved as catalysts in almost every chemical transformation, i. e. metabolism processes. They reduce the activation energy required for any reaction and thereby accelerate or enable a reaction (for example, when it comes to body temperature). Many of the 700 known enzymes are complex proteins with very specific effects. Enzymes usually have systematic names ending in *-ase*. The 'first name' indica-

tes the effect of the enzyme (e. g. dehydrogenases), or designates the substrate that is hydrolytically split (e. g. amylases).

3 A distinction is made between six main classes:

1. Oxidoreductases
2. Transferases
3. Hydrolases
4. Lyases
5. Isomerases *and*
6. Ligases

EU Water Framework Directive

The European Water Framework Directive (EU WFD) that came into force on 22.12.2000 standardises the requirements for water pollution control in Europe. A large number of the more than 20 previous directives concerning EU water pollution control are merged in the WFD.

eutrophication

1 The enrichment of fresh and salt water with nutrient salts, and particularly with phosphorus and nitrogen compounds, which accelerates the growth of algae and higher forms of plant life.

Source: DIN EN 1085

2 Nutrient enrichment in a water body and the associated excessive growth of aquatic plants (e. g. algae, pond weed). Large quantities of nutrients (especially phosphate and nitrate) can get into water bodies when carried by wastewater (including faeces and detergent / cleaning agent residues) and the run-off from agricultural areas (fertilisers); they then accelerate the growth of aquatic plants. Plants will increasingly die off, and their subsequent decomposition consumes excessive amounts of oxygen. If the water's oxygen content falls below a specific lower limit, the degradation of organic pollutants by aerobic bacteria ceases. When it comes to the subsequent decomposition processes caused by anaerobic bacteria, toxic substances such as hydrogen sulphide, ammonia or methane can be formed. The water body then reaches a 'tipping point' where fish die and noxious odours are produced.

Wastewater plants with advanced purification (tertiary purification stage) can considerably decrease the nutrient load in water bodies.

excess sludge

Sludge removed from an aeration plant; also known as surplus activated sludge.

Source: DIN EN 1085

F

faecal sludge

Sludge that accumulates during the treatment of wastewater in small-scale sewage plants (domestic sewage treatment plants).

fauna

(Latin) The animal world.

Federal Water Resources Act

Wasserhaushaltsgesetz (WHG). The law regulating the biological water balance (WHG, BGBl.1 p. 2585 dated 31 July 2009) came into force on 1 March 2010; at the same time, the old version of the WHG became invalid. Article 2 of the WHG (material area of application) defines those water bodies which the Act applies to:

1. Surface waters
2. Coastal waters
3. Groundwater

filter resistance

The loss of pressure provoked during the filtration process as a result of the loading of the filter medium.

Source: DVGW W 213-1: *Filtration methods for particle removal; Part 1: Basic concepts and principles*.

filtration

The removal of substances from water by passing it through granular or porous materials.

Source: DIN 4046

filtration velocity

The volume flow of filtrate in relation to the effective filtration area.

Note 1: In the case of membrane filters, the filtration velocity is usually described as permeate flux or filtrate flux.

Note 2: Normal units are $m^3/(m^2 \cdot h)$ or $l/(m^2 \cdot h)$.

Source: DVGW W 213-1: *Filtration methods for particle removal; Part 1: Basic concepts and principles*

final sedimentation tank

A settling tank to separate activated sludge or trickling filter sludge from the outflow of aeration tanks or trickling filters.

Source: Lexikon der Abwassertechnik, 7th Edition

final sedimentation

The final phase of biological wastewater purification, which comprises primary settlement (mechanical stage), aeration tank or trickling filters, and final sedimentation. The separation of the purified wastewater from the biological sludges involved in the purification process.

floating sludge

Solids separated from wastewater or sludge, which then float to the surface.

Source: DIN EN 1085

flocculation

1 The formation of flocs that can be separated out. During flocculation, many small particles combine to form larger particles with the aid of long-chain organic molecules. The process is usually supported by mechanical, physical, chemical or biological agents. Substances that cause such flocculation are designated as flocculants.

Source: DIN EN 1085

2 A process used to treat drinking water and in wastewater purification.

3 A coagulant is added to the water, where it forms flocs that can be filtered or settled out. The flocs capture dissolved or very finely distributed substances, or they are physically bonded to the surface of the floc (adsorbed).

flotation

Also known as dissolved air flotation (DAF). A process whereby gas bubbles adhere to suspended matter, which is then floated to the surface of a liquid.

Source: DIN EN 1085

flue gas

The gas produced during the incineration of organic substances; in addition to CO_2, it contains other gases from the materials incinerated as well as dust particles. Waste gas purification is thus required before it can be discharged into the air.

Source: Lexikon der Abwassertechnik, 7th Edition

foul wastewater

Water that has been altered through use, and water that has been introduced into a drainage system (wastewater).

Source: DIN EN 752-1

Freundlich adsorption isotherm

The empirical correlation between the loading of activated carbon and the concentration of the adsorbate in the water (which is kept in equilibrium with it), based upon a constant temperature (isotherm).

fruit water

Fruit water designates the water contained in a product (such as potatoes) at the time of delivery; for example, it is then removed during the production of potato starch.

G

grit chamber

1 A construction to separate grit, sand or similar mineral solids from wastewater.

Source: DIN EN 1085

2 Part of the mechanical wastewater purification process to remove sand from wastewater. The flow velocity of the wastewater must amount to no more than 0.3 m/s (= 1.1 km/h) in order to sediment grains of sand and other material ($d > 0.2$ mm). Sedimentation is achieved by reducing the flow velocity, and lighter substances are carried further by the flow. Grit chambers are deployed before pumping stations and in clarification basins in order to avoid hardening and unwanted sand deposits.

groundwater

1 Water that is contained in soil or rock below the aquifer.

Source: DIN ISO 11074

2 A subterranean water body (standing or flowing) which fills cavities in the earth's crust. When it flows through rock, the water dissolves minerals such as alkalis, sulphates, chlorides, etc. For this reason, all groundwater has a composition that corresponds to the geological structure of its river basin.

Source: Lexikon der Abwassertechnik, 7th Edition

3 The layers covering the groundwater as well as the aquifer form a natural filter system which to a large extent protects the groundwater from pollutants. However, the filter effect very much depends on the size and composition of the relevant grains and particles. Karst groundwater is generally much more susceptible to pollution than groundwater in porous material. Natural (unpolluted) groundwater contains no pathogenic bacteria or pollutants, which means it is preferred for the supply of drinking water. The natural purification capacity of aquifers and the layers that cover groundwater is, however, often inadequate when faced with vast

numbers of anthropogenic pollutants. Preventative groundwater protection is therefore an important task within water management.

H

hazardous substances

Hazardous substances are substances or classes of substances that are deemed hazardous as a result of their toxicity, longevity, ability to accumulate, or a carcinogenic, teratogenic or mutagenic effect. (See also: water pollutants).

heavy metal

Metals with a density > 4.6 g/cm^3 and/or a specific weight > 5 mN/cm^3. Heavy metals such as chromium, nickel, copper, zinc, cadmium, mercury and lead can be found throughout the environment. From a biochemical perspective, they to some extent belong to the trace elements. Some heavy metals (e. g. copper, zinc, manganese) are essential plant nutrients, while others (e. g. cadmium, mercury, lead) are only familiar as pollutants. Heavy metals become a problem for the environment if they pollute it via solid waste, wastewater, and waste gases.

Henry's law

A law concerning the solubility of gases in liquids. It states that at a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.

herbicide

1 Weed killer.

2 A substance or mixture of substances that destroys plant life. Generally speaking, this term is only applied to substances that selectively kill off weeds.

heterotrophic

1 (*heteros* Gk. = alien; *trophe* Gk. = food); feeding on organic substances only.

2 A term describing the nutritional type of organisms that require organic substances (proteins, fats, carbohydrates) to build up their bodily substance. For example, this includes fungi and bacteria. (See also: autotrophic).

hydrocarbon

1 Organic compounds consisting entirely of carbon and hydrogen; sometimes of major (practical) importance as fuels. Sometimes not (or not easily) biodegradable, or can be injurious to health (carcinogenic).

2 Abbreviation: HC. Chemical symbol: C_xH_y. Organic compounds consisting of carbon and hydrogen; they are the parent substances of all organic compounds. The lower branches are odourless, combustible gases; the middle branches are mostly liquids similar to petrol and petroleum; the higher ones are solids. A distinction is made between aliphatic, alicyclic and aromatic compounds. Amongst other things, hydrocarbons are of major importance as fuels or combustibles (natural gas, propane, petrol, heating oil, etc.). Hydrocarbons are used as a raw material in the chemical industry.

hydrocyclone

Hydrocyclones are centrifugal separators which are used to remove the sand from industrial wastewater and sludge (as well as thicken it).

I

indirect discharger

1 Indirect dischargers are businesses or private households that introduce their wastewater into the public sewage system. The wastewater is purified in municipal wastewater plants and then fed into the receiving water. As specified by the Wastewater Charges Act, indirect dischargers pay levies to the relevant local authority.

2 Wastewater dischargers that discharge their wastewater into water bodies indirectly rather than directly, via the public sewage system and municipal wastewater plants. (See also: direct discharger).

industrial wastewater

1 Wastewater from industrial enterprises (See also: commercial wastewater).

Source: DIN EN 1085

2 Industrial wastewater that mainly contains organic constituents which can be degraded (e. g. from the numerous sectors linked to the manufacture and/or processing of food and drink) can be successfully treated in biological wastewater plants; if there are high concentrations of pollutants, this can also occur in multi-stage plants, with degradation rates of up to 99 %. Even persistent organic constituents (for example, in wastewater from the chemical industry or petroleum processing) can to a very large extent be degraded in high-performance biological wastewater plants, often in combination with other wastewater purification techniques (such as flocculation / precipitation, filtration, flotation). Industrial wastewater or partial flows of wastewater that are particularly loaded with organic substances can be treated by using aerobic processes (in biogas plants) or thermally too, in which case the organic load is used to obtain energy. Wastewater with

mainly inorganic constituents (e. g. from machine and vehicle manufacturing, metal extraction and processing, treatment of metal surfaces) can be subjected to chemical / physical treatment processes, which often allows one to recover valuable substances such as metals. In many cases, the noxiousness and quantity of industrial wastewater or partial flows of wastewater can be reduced by introducing manufacturing processes that create little or no wastewater. Thermal power stations supplying electricity to the public mainly discharge large quantities of cooling water directly into water bodies.

infiltration water

Unwanted effluent in a drainage system. For example, groundwater that has infiltrated as a result of leaks; drainage water or surface water introduced as a result of faulty connections; surface water that has penetrated into the wastewater channel through manhole covers.

inflow

The volume of water flowing into a space within a unit of time. Formula symbol: Q_i; unit: m^3/s or l/s.

Source: DIN 4044

integrated environmental protection

Integrated environmental protection is understood to mean any measure whose objective is to avoid or minimise emissions in the early stages of production, and to save resources. The task is characterised by the use of key words: avoid, minimise, and recycle.

ion exchangers

Ion exchangers are natural substances (for example certain clay minerals) or deliberately synthesized resins containing positive ions (cation exchangers) or negative ions (anion exchangers) that exchange with those ions in solution having a greater affinity for the exchanger. For example, they are used to soften water (exchanger resins), in medicine (ion substitution), or in wastewater treatment.

L

loading

1 In the case of adsorption, the quantity of adsorbate that is adsorbed per unit of mass of the adsorbent.

2 In the case of filtration, the quantity of filtered-off substances that is absorbed per unit of mass or volume of the filter medium.

loss on ignition

1 The per cent by weight of dry mass that is lost when a sample previously heated to 105 °C is ignited; corresponds to the organic part of the dry mass.

2 The weight loss of a dry solid substance after incineration.

M

management plan

1 The management plan specified by the EU Water Framework Directive (EU WFD) for the river basin / catchment area of a water body contains measures deemed necessary to transform the water bodies into the required 'good ecological status', or in the case of 'heavily modified' and 'artificial water bodies' into 'good ecological potential' (including an estimated schedule for the carrying out of these measures).

2 As specified by Article 36b WHG, old version, plans which must be established by the *Länder*, and which must take account of the protection of water bodies, the preservation of groundwater supplies, and various usage requirements.

Source: Lexikon der Abwassertechnik, 7th Edition

mechanical wastewater purification

The first treatment stage in municipal wastewater plants. Pollutants are separated out from the wastewater with the aid of raking, screening / sieving, grit chambers and settling tanks (the sedimentation principle). By using mechanical wastewater purification, approximately 30 % of the contaminants (measured as BOD_5) can be removed from the water; this includes floating pieces of wood, metal and plastic containers, fabric remnants, sand, mineral substances, and faeces. Mechanical wastewater purification on its own is insufficient if water bodies are to remain clean, because suspended and dissolved substances are not removed.

membrane filtration

Membrane filtration is a separation process which, unlike conventional filtration, allows one to separate different types of molecule from one another. Example: the salt dissolved in seawater can be separated out via membrane filtration so that drinking water can be obtained.

membrane technology

See: membrane filtration.

membrane process

1 A process that removes very fine particles or even dissolved substances from water using a filter attached to a supporting layer.

2 Membrane processes allow fine purification of water without the use of chemicals; they include reverse osmosis, microfiltration and ultrafiltration. Reverse osmosis is, among other things, used for the treatment of landfill leachate and the desalination of seawater. Ultrafiltration is mainly used to separate emulsions (e. g. for the separation of oil from cleaning baths).

mercury

1 A heavy metal which in certain concentrations possesses a toxic effect; it is taken into account when ascertaining pollution units, as specified by the Wastewater Charges Act. In accordance with the Sewage Sludge Ordinance, it is a restricted constituent of sewage sludge when intended for agricultural utilisation. Limit value = 8 mg/kg DM.

2 The only metal that is liquid at room temperature; it possesses less electrical conductivity than most other metals. In its pure state, the metal is of a silvery appearance. The vapours from the metal are harmful to health; chronic damage as a result of lengthy exposure includes sleeplessness, character change, restlessness, trembling hands, so-called *tremor mercurialis*, and kidney damage in cases of very lengthy exposure. All these symptoms are reversible so long as no serious kidney damage has occurred. Mercury dissolves a range of metals by forming amalgams (mercury alloy). Mercury has many uses (physical measuring instruments, commutators, cathode metal in electrolysis, etc.). By contrast, mercury compounds no longer have a large number of important applications because their use as a mordant for cereals (slimicides) and during the manufacture of paper has long since been forbidden in the Federal Republic of Germany.

metabolism

The totality of chemical conversion in the bodies of living beings. A distinction is made between constructive metabolism (assimilation) whereby substrate is converted into new cell substance, and energy metabolism (dissimilation) whereby the oxidation of organic compounds supplies energy for constructive metabolism.

Source: Lexikon der Abwassertechnik, 7th Edition

mixed wastewater

According to Appendix 22 of the General Administrative Framework Regulation on Minimum Requirements for the Discharges of Wastewater into Waters, this applies to wastewater whose load of pollutants essentially originates from wastewater (of varying types and origins) that flows from an industrial enterprise.

model

The schematic reproduction of a system with reference to selected characteristics and procedures, e. g. for a river basin, a watercourse, or a body of groundwater.

municipal wastewater

Wastewater from households and industrial and commercial premises.

N

nitrate respiration

The process of respiration used by some anaerobic organisms, in which nitrate rather than molecular oxygen is used to oxidise organic molecules to obtain energy.

nitrificant

Bacteria which use oxidation to convert ammonia and/or ammonia compounds into nitrous acids and their salts and/or nitric acids and their salts.

nitrification

1 The oxidation of nitrogen compounds into nitrites and nitrates with the aid of bacteria. The oxidation of ammonium nitrogen (NH_4) by autotrophic bacteria (nitrosomonas) to form nitrite (NO_2), and by nitrobacter to form nitrate (NO_3). In principle, nitrification only occurs following further oxidation of the carbon compounds, and presupposes low sludge loading (< 0.15 kg BOD_5/kg TS·day) and/or a high sludge age, sufficient oxygenation, and wastewater temperatures above 10 °C.

Source: Lexikon der Abwassertechnik, 7th Edition

2 Oxidation of ammonium by microorganisms, normally with nitrate as the end product.

Source: DIN EN 1085

nitrification inhibitors

Chemical substances which, as a result of damaging nitrificants, inhibit or completely suppress nitrification. They can be used to achieve a delayed nitrogen effect as well as a reduced nitrate content in plant crops.

nitrogen

A non-metallic element with the chemical symbol N; a colourless, odourless and tasteless gas that forms the majority of air in the atmosphere. Nitrogen is one of the nutrients required to build cell substance.

nutrient

The totality of organic and inorganic substances necessary for the sustentation of organisms, e. g. C, O, H, N, S, P and nutrient salts.

Source: Lexikon der Abwassertechnik, 7^{th} Edition

O

obligation to dispose of wastewater

The Federal Water Resources Act stipulates that local authorities are obliged to dispose of wastewater. This encompasses the collection, treatment, discharging and percolation of wastewater together with the stabilisation and dewatering of sewage sludge resulting from wastewater treatment.

organic

Formed from living organisms.

osmoregulation

The ability of organisms to actively regulate the substance concentration and osmotic value of their bodily fluid (e. g. blood, cytoplasm) and thus keep it constant above a certain range regardless of the concentration of the surrounding medium.

osmosis

(*osmos* Gk. = to squeeze out); the migration (diffusion) of water or other solvents from solutions of varying concentration through semi-permeable walls in order to balance out the differences in concentration to the greatest possible extent. A semi-permeable membrane is permeable for the solvent, and impermeable for the substance that is dissolved. The rate of migration depends upon the size of the particles, the temperature, the difference in concentration, and the size of the pores in the semi-permeable membrane. The transport of substances in plant and animal cells is to some extent based on osmosis.

oxidation

In the original meaning of the word, oxidation refers to a reaction whereby a substance combines with oxygen. These days, oxidation / deoxidation is generally understood to mean a reaction that transfers electrons: oxidation is the release of electrons.

oxygen

A chemical element with the symbol O and atomic number eight. Oxygen is the most common element on Earth, and is a colourless and odourless gas which constitutes 20.942 % of the air. It is involved in many incineration and corrosion processes. Most living creatures in water require oxygen to survive, so dissolved oxygen also plays an important role in the ecological stability of water bodies.

oxygen deficit

The shortfall of oxygen in water when compared to oxygen saturation in mg/l or % of saturation.

oxygen demand

See: Biochemical Oxygen Demand, Chemical Oxygen Demand

oxygen depletion

Oxygen depletion refers to the consumption of oxygen during the degradation of organic constituents by microorganisms in water bodies. The amount of oxygen is stated in mg/l.

oxygen saturation

The largest quantity of dissolved molecular oxygen (mg/l) that can be contained in water when atmospheric oxygen and oxygen dissolved in water are in equilibrium, dependent on temperature, pressure, and dissolved substances. The saturation value at 0 °C is 14.6 mg O_2/l, and at 20 °C falls to 9.1 mg O_2/l

P

parasite

An organism that lives on or inside another organism, and obtains its food or some other benefit from its host without providing anything of equal value in return. It can harm the host by adversely affecting its organ functions, destroying cells, and depriving it of important nutrients, although it doesn't normally kill it. The acquisition of food from another organism is called parasitism.

pasteurisation

A process intended for the inactivation of microorganisms, particularly pathogens, or to reduce their concentration to below a predefined value as a result of increasing the temperature over a sufficient period of time.

Source: DIN EN 1085

permit

Within the context of the Federal Water Resources Act, a generally envisaged authorisation to use a water body or its constituent parts. An administrative act that can be revoked, normally with constraints and time limits. Reasons must be provided for any revocation, and it is also subject to legal verification.

pH value

1 The pH value is the negative decimal logarithm of the numerical value of hydrogen ion activity, stated in terms of mol/l. As a result of ion interactions, the activity of the hydrogen ions is somewhat less than the concentrations *(DVGW W 214-1: Entsäuerung von Wasser-Teil 1: Grundsätze und Verfahren)*. At 23 °C, the sum of the pH value and pOH value is always 14. At the same pH value and pOH value, i. e. pH = 7, a solution is neutral. Acids have a pH of less than 7, while bases have a pH of more than 7.

2 A measure of the concentration of hydrogen ions, and thus the concentration of acid in aqueous solutions (an acid is a substance that is able to form hydrogen ions in a solution of water). The lower the pH value, the more acid the solution.

Example: water with a hydrogen ion concentration of 10^{-4} mol/l or 10^{-4} g/l has a pH value of 4; if the concentration of hydrogen ions is 10^{-5} mol/l, the water has a pH value of 5.

Pure water has a pH value of 7 (neutral point); at higher pH values, the water demonstrates alkaline behaviour (leachate). pH values range from 0 to 14. The noxious effect of many substances often depends on their pH value.

phosphate elimination

Phosphate elimination is essentially based on treatment with precipitants or the biological removal of phosphate from wastewater. For example, phosphates are precipitated with aluminium sulphate, iron(III) chloride, or calcium carbonate. Phosphate elimination can at the same time be carried out via biological wastewater purification in an aeration plant (so-called simultaneous precipitation), as primary precipitation in primary settlement, or in special precipitation and final sedimentation tanks (tertiary purification stage). The foundation of biological phosphate elimination is the ability of certain strains of bacteria to absorb phosphorus beyond the level required for cell growth and store it in the form of polyphosphates. The bacteria absorb an increasing amount of phosphorus if they are exposed to a rapid exchange of anaerobic and aerobic conditions.

phosphorus

An element with the atomic weight 30.97 u and chemical symbol P. It is important for living beings, as a building block of cells, and is involved in metabolism.

Phosphorus is an essential nutrient that controls the eutrophication of water bodies. An excess of phosphorus can get into water bodies via municipal wastewater or agricultural inputs (slurry).

The majority of total phosphorus in wastewater is present in inorganic dissolved form, and essentially consists of orthophosphate. In addition, a small part of the phosphorus is organically bonded, present in dissolved and non-dissolved form. Condensed phosphates and organic phosphorus fractions are to a large extent already converted into orthophosphate in the sewer system and during wastewater purification processes.

Phosphorus mainly enters wastewater as a result of faecal excretions and the use of detergents. Legal restrictions on the phosphorus content of detergents have markedly reduced the phosphorus load and thus also the phosphorus concentrations in raw wastewater. An inhabitant-specific phosphorus accumulation of around 2.5 g/person/day is currently indicated.

phosphorus elimination

1 A process whereby the ability of certain strictly aerobic classes of bacteria to store excess phosphate is used to remove phosphate from wastewater. In order to supply energy whilst residing in an anaerobic milieu, strictly aerobic bacteria can develop the ability to store large quantities of polyphosphates under aerobic conditions. Under anaerobic conditions, these polyphosphates go into solution again (energy supply); the solution rate is increased by the presence of readily biodegradable organic substances.

Source: Lexikon der Abwassertechnik, 7^{th} Edition

2 In many cases, phosphorus is the minimum factor for water bodies. This means that every increase in the amount of phosphorus in a water body leads to a corresponding increase in the biomass. Eutrophication can be effectively controlled by reducing the discharge of phosphorus into water bodies.

The reduction of phosphorus in the outflow of wastewater plants is very important. The concentration of phosphorus in wastewater plants can be reduced by:

- Incorporating it into biomass and the removal of excess sludge
- Accumulation of polyphosphate in bacteria cells, and sluicing out with the excess sludge (biological P-elimination),
- Chemical precipitation and separation of the precipitated sludge from the wastewater (chemical P-elimination)

Degradation experiments using UV rays have shown that phosphonates (see: chelating agents) can be eliminated via photodegradation (with and without iron), especially as a result of photo-Fenton oxidation. Elimination via adsorption has also been observed.

See also: phosphate elimination.

physical processes to convert soluble compounds

See: precipitation

phytoplankton

Vegetable, photoautotrophic plankton, mainly comprising microscopically small algae and bacteria.

plankton

1 (*plagktos* Gk. = wandering); the totality of small living beings (zooplankton) and plants (phytoplankton) floating in water; amongst other things, they float as a result of flagellar movements, special jointed appendages, or gas vacuoles. Assimilating phytoplankton which are reliant on the light zone (especially the tiny nanoplankton which consist of cells smaller than 0.05 mm in diameter) are without exception food for zooplankton, and the latter are in turn food for many aquatic animals. One litre of seawater contains 3,000–100,000 plankton organisms.

2 A biocoenosis in the pelagic zone: organisms floating freely in water whose proper motion is generally limited when compared to the movement of water, so they drift passively.

planted soil filters

Planted soil filters (as defined by Worksheet DWA-A 262) are sand or gravel beds planted with reeds (helophytes) which are used for the biological purification of wastewater. This wastewater has had sludge, rough waste materials and floating matter removed from it, and may to some extent have been biologically pre-treated too. It is subsequently made to flow through the soil filter, either vertically or horizontally. The modes of action in the beds are characterised by complex physical, chemical and biological processes which are produced by the interaction of filter material, helophytes, microorganisms, pore air and wastewater. Biological purification processes are essentially based on the metabolic activities of microorganisms living in biofilms on the filter material as well as on plant roots. During the vegetation period, the plants can noticeably influence the water and nutrient balance of the soil filter. Planted soil filters (or constructed wetlands) allow the build-up of sludge which comprises the sum of the biomass that has been formed and the accumulated organic and inorganic constituents.

polishing pond

A pond for the post-treatment of purified wastewater, e. g. via the sedimentation of very small particles. It improves residual organic pollution, settleable solids, hygienic composition, and to a minor extent the elimination of nutrients too. Also referred to as a *maturation pond*.

pollutant

1 A natural or anthropogenic substance which, even in low concentrations, influences biological processes and systems (toxic or ecotoxic effect), or which restricts the use of organisms and/or the environment (formation of residues).

2 As specified by the EU WFD: any substance that can lead to pollution, and especially substances listed in Annex VIII.

pollution

1 In this context: the direct or indirect release (as a result of human activity) of substances or heat into the air, water or soil which might damage human health, the quality of aquatic ecosystems, or those land-based ecosystems that are directly dependent on them. Furthermore, substances which cause damage to material assets, or which adversely affect or interfere with recreational value and other legitimate usages of the environment.

2 Unwanted substances in a material e. g. heavy metals, toxic organic chemicals (e. g. tar, phenol, PCBs), glass or plastic components, large stones / rocks, pieces of wood or coarse debris, extremely soluble salts, pesticide residues, pathogens, herbicides. See also: pollutant.

pollution unit

Also known as unit of noxiousness; a metric to ascertain the wastewater levy, as specified by the Wastewater Charges Act. One 'pollution unit' corresponds to the estimated annual amount of unpurified wastewater produced by one inhabitant. When ascertaining pollution units, one considers the annual quantity of wastewater together with the COD, phosphorus, nitrogen, AOX, mercury, cadmium, lead, chromium, copper, nickel, and fish toxicity.

polysaprobic

Strongly polluted with organic, oxygen-consuming substances.

population equivalent

1 A unit which allows one to compare commercial or industrial wastewater with domestic wastewater.

Source: Lexikon der Abwassertechnik, 7th Edition

- PE_{B60} means the population equivalent is based on the wastewater's Biochemical Oxygen Demand over 5 days, amounting to 60 g/(inhabitant · day).
- PE_{WW200} means the population equivalent is based on a wastewater volume of 200 l/(inhabitant · day).
- PE_{FS70} means the population equivalent is based on 70 g/(inhabitant · day) of substances in the wastewater that can be filtered off.

- PE_{KN12} means the population equivalent is based on 12 g/(inhabitant · day) of Kjeldahl nitrogen in the wastewater.
- PE_{P2} means the population equivalent is based on 2 g/(inhabitant · day) of total phosphorus in the wastewater.

2 One arrives at the population equivalent by relating it to the BOD_5 (Biochemical Oxygen Demand) values that have been ascertained for the different types of organic wastewater occurring as a result of various manufacturing processes (e. g. breweries, the chemical industry, starch factories, sugar refineries, cellulose and paper manufacture, etc.). This figure indicates how many people would produce a daily quantity of wastewater whose BOD_5 corresponds to the daily production of pollutant load in commercial manufacturing.

Here are some population equivalents of wastewater from a selection of industries:

- Production / processing of 1000 litres of beer in a brewery = 20–280 PE
- Processing of 1000 litres of milk in a dairy (without cheese-making) = 25–70 PE
- Processing of 1 tonne of washing in a laundry = 350– 900 PE

Source: Imhoff & Imhoff: *Taschenbuch der Stadtentwässerung*, 29th Edition

precipitation

The conversion of soluble compounds into insoluble compounds via the addition of suitable chemicals. The resultant precipitation product can be separated off via a suitable physical procedure (e. g. sedimentation, flotation, filtering).

primary settlement tank

A settling tank in which the majority of settleable substances are separated via sedimentation from raw wastewater or pre-treated wastewater.

Source: DIN EN 1085

primary sludge

Sewage sludge that accumulates as the result of the removal of (usually undissolved) wastewater constituents during the mechanical treatment stage, using the effect of gravity (after raking and grit chambers). During primary settlement, it accumulates after scraping in the pump sump and is generally transported directly into the septic tank. Primary sludge to a large extent consists of organic substances such as faeces, fruit and vegetables, fabrics, paper, etc. The consistency is mushy, with a water content of between 93 % and 97 %.

product-related environmental protection

When it comes to product-related environmental protection, the main focus of interest includes the product-related consumption of resources, usage properties, lifetime, and recycling and disposal options. It is also referred to as *cleaner products*.

production-related environmental protection

Production-related environmental protection is understood to mean any measure that aims to reduce the amount of resources consumed during production, together with the reduction of emissions resulting from production.

production-integrated environmental protection

The underlying principle of production-integrated environmental protection is that avoidance measures should take priority over recycling measures, while the latter should take priority over disposal measures. It is also often referred to as *cleaner production*.

Production-integrated measures mean that unavoidable residual substances must, if possible, be reused in other processes, as raw or auxiliary materials. Production-integrated environmental protection should mean that emissions are treated so that they can be recycled.

process-integrated environmental protection

The most important objectives are:

- To minimise the consumption of energy and raw materials
- To optimise product yields
- To achieve low-emission (or preferably) emission-free processes and installations

By achieving these subsidiary targets, one can come as close as possible to the overall goal of eco-friendly production.

Process-integrated environmental protection measures generally contain relevant procedural improvements or adjustments, such as the development of low-residue or residue-free processes. Process-integrated environmental protection therefore takes priority over production-integrated environmental protection.

pyrolysis

1 A physical / chemical process whereby organic substances are transformed from their solid or liquid state into their gaseous state under the influence of higher temperatures. In current parlance, without oxygenation (= degasification), the objective being to obtain utilisable gases.

Source: Lexikon der Abwassertechnik, 7th Edition

2 The conversion of organic material via heat, in the absence of oxygen or with a limited supply of oxygen. Pyrolysis produces combustible gas, oil, tar and solid residues in quantities that depend on the amount of air present, the reaction time, and the temperature.

R

rapid filters

Filters that are operated at filtration velocities of several m/h, and whose filter medium consists of granular materials; they are equipped with permanently installed rinsing devices (DVGW W 213-1).

raw sludge

Sewage sludge that has not yet been stabilised is called raw sludge. Raw sludge is also described as fresh sludge, and is the untreated sludge from a wastewater treatment plant. Raw sludge tends toward acid fermentation and the formation of unpleasant smells.

Source: DIN EN 1085

receiving water

Any water body into which water or wastewater is fed.

Any type of water body such as the sea, a river, lake or aquifer into which wastewater from a sewage system is fed.

Source: DIN EN 1085, DIN EN 752-1

redox potential

1 Also known as reduction potential or oxidation-reduction potential (ORP). A parameter to assess the reduction or oxidation capacity of wastewater. The rH scale represents the negative logarithm of oxygen pressure and ranges from 0 to 42. rH values of less than 15 indicate reduction (digestion zone), while rH values of more than 25 indicate the oxidation zone.

2 An indicator to determine the biological self-purification capacity of water bodies.

reduction

In the original meaning of the word, reduction refers to a reaction whereby oxygen is removed from part of a compound. Oxidation / reduction is nowadays generally understood to mean an electron transfer reaction: reduction is the take-up of electrons.

residue on ignition

The per cent by weight that remains as mineral residue after a sample that has previously been dried at 105 °C is ignited.

Source: DIN 4047, Section 10

retention time

In process engineering / technology, the usual term for flow time.

return activated sludge

Part of the activated sludge process: activated sludge that is separated out from the mixture of wastewater and activated sludge during final sedimentation and then returned to the aeration tank.

Source: DIN EN 1085

Reynolds number

The Reynolds number allows one to calculate the transition from laminar to turbulent flow, and expresses the hydraulically significant properties of the flowing substance via its kinematic viscosity. Formula symbol: Re; unit: dimensionless.

$$Re = \frac{v \cdot l}{\nu}$$

roughness

1 Flowing water is slowed down as a result of friction, for example on the riverbed or embankments. The roughness of the surface it comes into contact with is a measure of the strength of this friction. Sills or coarse blocks of stone / rock increase the roughness of the river bed. In the foothills, the flowing water is slowed down by vegetation. High roughness leads to a reduction in mean flow rates, and the water level rises if the outflow remains steady.

2 When calculating pipelines and networks of pipes, a distinction is made between the following roughness values:

- k = absolute roughness
- k_s = the roughness of sand
- k_i = integral roughness; the operational roughness of any factor that influences loss of pressure (in accordance with W 302)

k_i roughness as set out in DVGW Worksheet W 302 does not specify the measurable level of roughness in a single pipe or section of pipework, but is instead understood to be a measure of the hydraulic behaviour of the entire pipeline and/or respective network of pipes.

S

saprobes

(*sapros* Gk. = putrid; *bios* Gk. = life): specific organisms living in polluted water bodies, such as protozoa, bacteria and fungi. Saprobes gradually decrease the organic content of water (mineralisation) and thus achieve biological self-purification of water bodies.

saprobic system

A way of classifying water bodies according to biological perspectives, and which serves to rate water quality. Depending on the level of water pollution, characteristic biocoenoses appear; the list of organisms represented in them serves as a yardstick for dividing water bodies into quality classes.

Quality Class 1 means no (or minimal) water pollution. It is described as oligosaprobic, and indicates a high oxygen content with a low concentration of fertilisers. Characteristic organisms include insect larvae and diatoms.

Quality Class 2 means moderate pollution. It is described as beta-mesosaprobic, and the water body has a low concentration of oxygen. The fertiliser salts are mainly present in the form of oxygen-rich compounds. Snails, crustaceans, green algae and higher aquatic plants are characteristic.

Quality Class 3 (alpha-mesosaprobic) is characterised by a low oxygen content. The fertiliser salts often occur as oxygen-free compounds. The percentage of autotrophic plants is small, so that biological oxygen production is not very great. Some typical organisms are leeches, bristleworms and ciliata.

Quality Class 4 indicates very major pollution, and is described as polysaprobic. The oxygen concentration is very small; by contrast, ammonia or even hydrogen sulphide often occur. Oxygen-releasing plants are not present, and the biocoenosis is characterised by bacteria and bacteria-eating ciliata.

Source: Lexikon der Abwassertechnik, 7th Edition

screen

A mechanical device in wastewater plants to retain coarse substances via parallel rods. The substances that are thereby separated off are known as rakings or screenings. A distinction is made between fine screens (gap between rods = 15–40 mm) and coarse screens (gap between rods = over 40 mm).

sedimentation

1 The separation of solids from water via gravity.

Source: DIN 4046

2 The deposition of constituents.

Source: DIN 4049, Section 1

secondary sludge

Sludge removed from the secondary and/or biological purification phase. It is generally referred to as excess sludge.

Source: DIN EN 1085

seepage pit

Seepage pits (or *infiltration ditches)* are facilities intended for the 'natural' aerobic biological post-purification of wastewater that has previously been subjected to primary biological clarification. At the same time, any secondary sludge arising is separated from the purified wastewater, and is then stored, treated and finally disposed of.

Procedure: wastewater that has previously been well clarified is fed in perforated pipes into parallel pits where it trickles through a filter of fine gravel, and is collected in drainage pipes that lie below it; it is then introduced into a water body. The microorganisms present in the fine gravel ensure biological post-purification. Oxygen is supplied via the air which, following each loading process, is drawn into the gravel by the wastewater as it trickles further downward. High oxygenation can duly be achieved via intermittent loading of the seepage pit.

self-purification

A process whereby water constituents are separated out by biological, chemical or physical processes, or altered in such a way that their negative impact on water quality is reduced.

Source: DIN 4045

semi-natural wastewater treatment process

A distinction is made between wastewater treatment processes that use a degree of technical equipment and other ecological functions or effects.

Semi-natural wastewater treatment processes use a deliberately structured, semi-natural but artificially created environment comprising water, soil, and possibly plants in order to promote the biological degradation processes of microorganisms (the definition is meaningful in terms of distinguishing this from natural and technical / technological processes).

Ecological aspects: partial integration into natural ecosystems, semi-natural structure with feedback loops, weak volumetric loading, little formation of sludge, additional habitat for secondary species, minor use of external energy, influence of light and temperature.

Semi-natural wastewater treatment processes are distinguished by hydraulic loading, oxygenation, biomass concentration, oxidation rate, operational requirements, and the need for large volume and a generous amount of space.

service water

1 Surface water or recycled wastewater used for washing machines, flushing toilets, and irrigation (i. e. not drinking water).

2 Raw water (e. g. groundwater or surface water) that is treated – in a variety of ways, depending on the technical use it is intended for (such as cooling water or boiler feed water).

3 See also: process water

settling velocity

1 The speed at which solids move in a vertical direction (from DIN 4044: 1980-07). Formula symbol: v_s; unit: m/s

2 The speed at which a particle settles in water under the influence of a gravitational field, expressed in [m/h] or [m/s].

sewage sludge

1 Water-containing substances (except for rakings, screenings, and grit chamber trappings) that can be separated out from wastewater.

Source: Lexikon der Abwassertechnik, 7^{th} Edition

2 A mixture of water and solids that accumulates during the mechanical and biological purification of wastewater, and during chemical / physical processes. A distinction is made between primary sludge, secondary sludge and tertiary sludge. Depending on the type / origin of the sludge, the water content ranges between 96 % and 99.5 %.

sewage sludge composting

A biological method for the treatment and stabilisation of sewage sludge. Decay (aerobic decomposition of solid organic substances) can occur in stacks or containers (so-called bioreactors) at temperatures of approximately 65 °C. The sewage sludge is previously mechanically dewatered to a water content of approx. 70 %. In addition to aeration, the admixture of structural material is required in order to achieve an optimal water content of 40–60 % for the rotting process. The resultant compost is hygienically clean.

sewage sludge dewatering

A sludge treatment process to further reduce the amount of water contained in sludge; it is also used to reduce the volume for subsequent disposal-oriented processes (e. g. drying, incineration), and is normally used with sludge that has already been stabilised (sewage sludge stabilisation). Mechanical processes are mainly used for dewatering: centrifuges or filter presses (e. g. chamber filter presses). Natural dewatering processes in drying beds, sludge ponds or sludge storage chambers have become less important as a result of the space required and problems with unpleasant smells. Depending on the process, the water content can be reduced to 60 %.

sewage sludge drying

A sludge treatment process to remove the residual water contained in mechanically dewatered sludge via vaporisation and evaporation. The objective of the drying process is to reduce the volume and increase the calorific value for subsequent thermal disposal (sewage sludge incineration). A distinction is made between partial and full drying, with which the water content can be reduced to 5–15 %. Fully dried sewage sludge can reach a calorific value of 9–12 MJ/kg, which corresponds to the calorific value of brown coal.

sewage sludge incineration

1 Oxidation at high temperatures of organic sludge constituents.

Source: DIN EN 1085

2 A sludge treatment process whose objective is to reduce its mass and volume. Incineration almost completely mineralises the organic constituents within sewage sludge, destroys pollutants contained within the sludge, and concentrates inorganic pollutants in the incineration residues and waste gas. A distinction is made between mono-incineration and co-incineration: in the latter case, sewage sludge is incinerated in conjunction with residual waste or other combustible materials.

sewage sludge humification beds

Sewage sludge humification beds are sludge drying sites where anaerobically or aerobically stabilised sludge is dewatered and 'refined'. This involves a simple basin dug into the ground (possibly lined with sheeting), the bottom of which is provided with a gravel drainage layer covered with humus. In a similar way to plant beds, the humus is planted with reeds and other hydrophytes, and the basin is then constantly fed with liquid sludge. The water that flows off via the drainage channel is discharged into the intake of the sewage treatment plant; the plants promote the evaporation of the sludge water, and the original amount of sludge is thus considerably reduced. The substrate that accumulates has hitherto been almost exclusively sent to landfill. Some other possible routes for reutilisation include agriculture and forestry (composting, land reclamation / recultivation) as well as thermal reutilisation.

Sewage Sludge Ordinance

Klärschlammverordnung (KVO): The Sewage Sludge Ordinance in Germany regulates the depositing of sewage sludge from wastewater purification plants onto areas that are used for agriculture, forestry or gardening. The Ordinance stipulates that the sewage sludge must be previously sterilised, and prescribes upper limits for seven heavy metals (lead, cadmium, chromium, copper, nickel, mercury, zinc). The Ordinance further regulates the intervals at which the sewage sludge can be deposited, and limits the annual amount. It is forbidden to deposit sewage sludge on areas used to grow fruit and vegetables, as well as on permanent grassland and areas that are used for agriculture, forestry or gardening.

Source: Sewage Sludge Ordinance

sewage sludge stabilisation

A sludge treatment process to promote the advanced degradation of the sludge constituents, to minimise pathogens, and/or for the purposes of disinfection and to minimise the formation of foul-smelling substances. A distinction is made between biological, aerobic sludge stabilisation processes (e. g. sewage sludge composting), biological anaerobic sludge stabilisation (digestion) and dual biological stabilisation processes (aerobic / anaerobic or anaerobic / aerobic). A further distinction is made between thermal stabilisation processes (incineration, gasification, pyrolysis) and chemical stabilisation processes (self-heating via the addition of calcium carbonate).

sewage sludge thickening

A sludge treatment process to concentrate the solids in sludge and/or to separate solids from liquids. It is applied to reduce the sludge volume, to improve process stability for subsequent sludge treatment processes, and to optimise costs (smaller containers, pumps, transport costs, etc.). The thickening process is based on the exploitation of the natural gravitational field (e. g. static thickeners, sieve reactors, screw compactors, belt thickeners, dissolved air flotation), or on the creation of an artificial field of gravity (centrifuges / decanters). Depending on the process, the water content can be reduced to 85 %.

sewage sludge treatment

See: sludge treatment.

simulation

The use of a model to describe the behaviour under specific conditions of the system that is being examined.

simultaneous precipitation

A chemical precipitation process whereby the precipitant (aluminium sulphate, iron chloride, iron sulphate) is added in the biological stage of the respective installation.

slow filter

An open filter that is constantly submerged during operation, with granular filter material and large surfaces but no permanently installed rinsing device. It is operated at very low filter velocities.

Please note: unlike infiltration basins, the filtrate from slow filters is collected and discharged in a controlled way (DVGW W 213-1).

sludge age

A term used in biological wastewater purification and the activated sludge process. It is a measure of the length of time a particle of suspended solids has been undergoing aeration, expressed in days. It is usually computed by dividing the weight of the suspended solids in the aeration tank by the weight of excess activated sludge discharged from the system per day. The sludge age therefore indicates how long (in theory) the sludge remains in the system before it is drawn off as excess sludge.

sludge analysis

A way of determining the distribution of grain / particle sizes.

Sludge analysis, which is also referred to as elutriation or wet analysis, is a mechanical separation process to determine the quantity of fine particles in a sample of sediment (dispersion analysis). It is suitable for particle sizes of $0.001\ \text{mm} < d < 0.125\ \text{mm}$ (cohesive soils).

Different-sized particles sink at differing speeds in standing water. The correlation between particle size, density and settling velocity is described by Stokes' Law.

Depending on the particle size, the particles settle at different speeds, so over time the distribution of particle size and distribution of density change, and this is measured via the ratio of the density of the liquid to the density of water. The densities determined via the immersion depths of the hydrometer provide the grain size distribution. (See also: DIN 18123).

sludge composting

A further (usually mechanical) stage in the process to reduce the water content of sludge.

sludge dewatering

Reducing the water content of sludge via one or more technologies, normally using natural or mechanical stages.

Verminderung des Wassergehaltes von Schlamm durch eine oder mehrere Technologien, üblicherweise mittels natürlicher oder maschineller Verfahrensstufen.

sludge list

The so-called 'sludge list' can be used as the basis for calculating an initial estimate of the sewage sludge accumulating in a wastewater plant; it draws upon a comprehensive collection of empirical values. The 'sludge list' was introduced by Imhoff in 1943 in the 10th edition of the *Taschenbuch der Stadtentwässerung*, since when it has been supplemented and corrected on many occasions. Even according to more recent surveys, the quantities for primary, excess and digested sludges that can be ascertained for a wastewater plant by using the sludge list still broadly coincide with the actual quantities of sludge in the wastewater plants that were examined, including installations with advanced wastewater purification.

sludge stabilisation

A sludge treatment process, particularly for the advanced reduction of odour-forming constituents and organic sludge solids. Some desired subsidiary goals include the improvement of dewatering capacity and the minimisation of pathogens. A distinction is made between aerobic stabilisation and anaerobic stabilisation (digestion).

sludge thickening

The first stage in the process to increase the concentration of solids in sludge, by separating them from water, e. g. by using gravity.

sludge treatment

The treatment of sludge for the purposes of recycling or disposal, e. g. via sludge thickening, sludge stabilisation, conditioning, sludge dewatering, drying, disinfection, ashing or incineration.

sludge volume

The volume of sludge contained in a litre of wastewater or wastewater mixed with activated sludge after a settling time of 30 minutes (in ml/l).

Source: DIN 1085

sludge volume index

(SVI) Corresponds to the sludge volume in millilitres occupied by 1 g of dry substance after a settling time of 30 minutes. The SVI serves to assess the settling properties of activated sludge.

small-scale sewage plant

Small-scale sewage treatment plants comprise several chambers which are used to treat domestic wastewater, with an effluent inflow of less than 8 cubic metres per day. The terms domestic sewage treatment plant or site treatment plant are also common in the relevant literature.

Source: DIN 4261 Section 1 / Sewage Sludge Ordinance

solubility

The maximum quantity of a substance that can be absorbed by a defined quantity of water in fixed pressure and temperature conditions via the formation of a saturated solution.

sorption

The assimilation of one substance by another with which it is in contact, or the assimilation of a dissolved substance by another solid or liquid substance.

stabilisation

A procedure to convert dissolved and particular substances into inorganic and very slowly degradable organic substances.

stabilised sludge

1 Sewage sludge that has been degraded by microorganisms to a state where it can be stored.

2 Sludge that has been treated so that at least one of the two main objectives of sludge stabilisation is achieved.

state of the art

1 Technical / technological possibilities developed to a given stage at a given time as far as products, processes and services are concerned, based on relevant verified insights from science, technology and experience (DIN EN 45020).

2 In some environmental legislation enacted by the Federal Republic of Germany (cf. Federal Water Resources Act, Federal Immission Control Act,

3 Closed Substance Cycle & Waste Management Act) this describes the development status of advanced processes, establishments and operational modes whose practical suitability seems assured when combatting environmental pollution. When determining state of the art, one makes particular use of processes, establishments and operational modes that have been tested in practice. State-of-the-art measures should guarantee the best (currently achievable) protection of the environment from damage and pollutants.

statute

1 The legislation applied by self-regulatory bodies, and local authorities in particular, to regulate their own affairs (e. g. development plan, wastewater statute, waste materials statute, tree protection statute).

2 The generic term for the basic regulation (constitution) laid down in writing of a legally constituted body (association, collective). It establishes the rules to regulate one's own affairs. Bodies governed by public law require their statute to be authorised by the supervisory body (key words: articles of association, local by-law, district ordinance). The statute is the product of self-regulation legislation.

stripping

Stripping describes how volatile constituents are driven out of liquids (e. g. highly volatile organically bonded halogens). Substances such as ammonia can be separated off by shifting the pH value. Stripping is usually carried out in columns in which plates or packing have been incorporated to improve the mixing of the gaseous and liquid phase.

submerged trickling filters

Components used for the aerobic biological purification of previously clarified municipal wastewater. They consist of cylindrical biofilm carriers for microorganisms which are mounted around a horizontal axis, in varying specifications. The cylinders are immersed to roughly half their depth in troughs of previously purified wastewater, and are set in slow rotation so that the microorganisms are alternately brought into contact with wastewater and air.

substance load

The total substance transport in relation to a water constituent over a certain period of time, e. g. annual chloride load. Unit: g, kg or Mg

substance load balance

The numerical comparison of the substance loads entering a system, remaining in it, and leaving it again.

surface aeration

A device in wastewater technology for the aeration of aeration tanks. Air is introduced via rotating spinners which are arranged vertically to the surface of the tank (rotation around a vertical axis) or via horizontally arranged drums / rollers that are equipped with paddles (rotation around a horizontal axis).

surface filtration

A filtration process whereby the particles that need to be filtered off are mainly retained on the surface of the filter medium (DVGW W 213-1).

surface water

Water from atmospheric precipitation which has not yet absorbed any substances from the surface.

Source: DIN EN 1085

suspended microorganisms

Also referred to as suspended biomass; microorganisms that are maintained in suspension in wastewater.

T

tensides

Detergent substances (including soaps) which reduce the surface tension of water and promote the removal of dirt. Tensides are used in many areas of industry. The tensides contained in detergents in the 1950s were not very susceptible to primary degradation, which led to the formation of foam on water bodies, and in some exceptional case even to foaming drinking water. This problem has been solved by the passing of the Detergents Act in 1961, although hard tensides are still insufficiently subject to biological degradation.

tertiary sludge

Sludge that is produced in the tertiary purification stage of a wastewater treatment plant, e. g. during the chemical precipitation of wastewater constituents (phosphorus precipitation).

toxicity

The state or quality of being poisonous; the degree of strength of a poison. See: hazardous substances

trickling filter

A support medium (mostly plastic) layered in containers which is used for the purification of biological wastewater; the layers are sprinkled with the wastewater. Microorganisms (microbial film) living on the trickling filters lead to the biological degradation of the dissolved organic constituents. Aeration occurs via the natural or artificial supply of air.

trophy

Also referred to as trophication (*trophe* Gk. = food). Nourishment, the supply of nutrients; intensity of primary production; biomass and metabolic rate of autotrophic organisms.

trophic level

The trophic level quantifies the degree of trophication in water bodies. If it is low, one refers to oligotrophic water bodies; a moderate trophic level is designated as mesotrophic, and a high trophic level as eutrophic or hypertrophic. The rise in the trophic level is referred to as eutrophication.

U

unaerated wastewater lagoon

1 A wastewater lagoon without any artificial aeration, in which aerobic degradation principally occurs; also known as an oxidation pond.

Source: DIN EN 1085

2 The purification processes in unaerated ponds or lagoons are similar to those occurring in standing or very slowly flowing water bodies. The input and mixing through of oxygen very much depend on climatic and meteorological conditions, so that, for example, the design data in Northern Europe cannot readily be transferred to warmer regions. The settleable solids contained in wastewater are deposited in the intake zone, where they decompose under anaerobic conditions. Generally speaking, the increase in the quantity of sludge in lagoons with a long retention time is limited.

usage of water bodies

A term taken from the Federal Water Resources Act which includes the following measures:

Withdrawing and diverting water from surface waters; banking up and lowering surface waters; removing solid substances from surface waters provided that this has an effect on the state of the water body or on water drainage; introducing and discharging substances into surface waters, including coastal water; introducing substances into the groundwater; withdrawing, pumping to the surface, guiding to the surface or discharging groundwater.

Furthermore, any measure that has a major adverse effect on the physical, chemical or biological composition of the water can constitute a usage in the meaning of the WHG, old version.

V

vapour condensate

Vapour condensate refers to the quantity of wastewater that is recondensed after an evaporation or drying process.

viruses

Pathogens: a large group of tiny, very diverse, autonomous particles of crystalline to organic (bacteriophages) macromolecular structure within the overall system of the cell metabolism of a living being.

Source: Lexikon der Abwassertechnik, 7th Edition

volume filtration

(Sub-surface filtration) A filtration process whereby particle separation is preferably achieved inside the filter medium rather than at the surface of the filter medium (DVGW W 213-1).

W

wastewater

1 Water composed of any combination of water discharged from domestic, industrial or commercial premises, surface run-off, and unintentional inflow of infiltration water.

Source: DIN EN 1085

2 Water whose properties have been changed by domestic, commercial, agricultural or other uses, and the water drained together with it during dry weather conditions (polluted water), as well as water running off and collected from built-up or paved or asphalted surfaces following precipitation (Article 2, AbwAG).

Wastewater can contain a variety of pollutants which can be subdivided into the following essential classes:

- Readily biodegradable organic substances
- Persistent organic substances
- Plant nutrients
- Heavy metal compounds
- Salts *and*
- Waste heat

In order to protect water bodies, the pollutants must be reduced as far as possible by treating the wastewater and deploying other measures.

3 In its narrower sense, water that is polluted as a result of domestic and/or commercial and industrial use, and whose quantity and composition vary greatly; likewise the precipitation water that runs off built-upon areas (roofs, roads). It contains dissolved, colloidal and particulate pollutants. The wastewater volume of towns and cities fluctuates in a broad range of between 50 to 400 l per day and inhabitant; the area of land required for a complete wastewater plant fluctuates between 0.5 and 2.0 m^2 per inhabitant.

Wastewater Association

A self-governing body resulting from the merger of several municipalities, and whose legal form is usually that of a special-purpose association. Its task is to jointly collect and treat wastewater.

Source: Lexikon der Abwassertechnik, 7^{th} Edition

wastewater charges

A levy has to be paid if wastewater is discharged into a water body. The levy is determined by the harmfulness of the wastewater, which is calculated and transformed into so-called 'pollution units' on the basis of the quantity of wastewater, the presence and quantity of the metals mercury and cadmium, oxidisable substances, and the toxicity of the wastewater for fish (fish toxicity). As a consequence of the law enacted in 1986, a levy also had to be paid from 01.01.1990 onward for the organic halogen compounds (AOX) and the metals chromium, nickel, lead and copper.

Wastewater Charges Act

The *Abwasserabgabengesetz* (AbwAG) is a federal law stipulating that a levy corresponding to the harmfulness of the wastewater must be paid for discharging wastewater into a water body. The levy is calculated on the basis of pollution units which take account of the following parameters: Chemical Oxygen Demand, phosphorus, nitrogen, AOX, mercury, cadmium, chromium, nickel, lead, copper, fish toxicity.

Wastewater Cooperative

1 The intention of Wastewater Cooperatives is to amalgamate the disposal of wastewater and thereby reduce costs.

2 A consortium whose objective is to jointly carry out wastewater purification on behalf of various businesses or municipalities, e. g. in a so-called 'central sewage treatment plant' for several locations. Water and Soil Associations constitute one form of Wastewater Cooperatives (example: *Wupperverband*). These associations can also consist of (or forcibly include) individuals and/or legal entities in civil law as well as landowners, mines, or members from industrial areas.

wastewater biology

Wastewater biology deals with the biological processes, organisms and conditions of life pertaining in wastewater or a natural water body that has been polluted with wastewater, together with its level of pollution.

wastewater discharge

1 Article 3 para. 1 No. 4 Federal Water Resources Act states that the discharge of wastewater into surface waters constitutes a usage, and as specified by Article 2 in conjunction with Article 7 WHG, old version, requires a permit. The 4^{th} Amendment to the WHG incorporates Article 7a into this legislation, a provision that is fundamental in terms of practice. It establishes the minimum requirements under which a permit to discharge wastewater can (only) be granted. The 5^{th} Amendment to the WHG has made this provision more rigorous: in future, state of the art must be complied with for wastewater containing hazardous substances; only if this is complied with can a permit for discharging be granted. With the approval of the *Bundesrat*, the Federal Government issues general administrative directives relating to minimum requirements for the discharging of wastewater which must correspond to generally accepted codes of practice and/or in the case of dangerous wastewater, state of the art (Article 7a para. 1 sentence 3 WHG, old version).

2 The sum of domestic, commercial and industrial wastewater discharge; $Q_{wd} = Q_d + Q_c + Q_i$

wastewater disposal

In its general sense, the return of wastewater into the natural water cycle.

Possible procedures:

- Discharge into a receiving water course (surface water bodies such as streams, rivers or lakes)
- Discharge into a municipal drainage system
- Agricultural wastewater utilisation
- Percolation or sinking
- Evaporation and incineration
- Transport to the sea
- Dewatering of sewage sludge in the context of wastewater purification, which is necessary in most cases.

wastewater disposal concept

The foundation for any planning of wastewater disposal facilities in rural areas should be a supra-regional wastewater disposal concept. This corresponds to the wastewater disposal plan specified in Article 18a (3) WHG, old version; legislation by the *Länder* (e. g. Articles 55, 56 Water Act of the State of North Rhine-Westphalia) regulates its content and obligations.

A wastewater disposal concept should contain:

- A definition of the area to which it applies
- Existing wastewater plants (sewage systems, small-scale sewage plants, local wastewater plants) and their technical and economic rating
- Measures necessary to protect water bodies, while taking account of legal provisions
- Alternatives and variants
- Short- and medium-term interim solutions (according to priorities) together with cos-

tings showing how one can gradually get closer to the target

wastewater disposal plan

Wastewater disposal plans (Article 18a para. 3 WHG, old version) are one of the planning tools specified by the Federal Water Resources Act. Wastewater disposal plans are established by the *Länder* in accordance with supra-regional perspectives (Article 18a para. 3 sentence 1 WHG, old version), and in the interests of the protection of water bodies should guarantee optimal wastewater treatment by establishing corresponding targets. The provisions set out by overall water management planning form the basis for the creation of wastewater disposal plans. In particular, wastewater disposal plans must specify the locations of important installations for the treatment of wastewater, their catchment area, basic features of the wastewater treatment, as well as who is responsible for the measure (Article 18a para. 3 sentence 2 WHG, old version). This list of the minimum content of any wastewater disposal plan is not exhaustive. It is left to the *Länder* to declare that individual provisions or every provision of a wastewater disposal plan are binding for other public authorities, planning agencies, bodies with an obligation to dispose of wastewater, and other third parties (Article 18a para. 3 sentence 3 WHG, old version).

wastewater disposal planning

(Article 18a para. 3 Federal Water Resources Act): is only concerned with a very restricted sub-area of water management, namely wastewater disposal.

The tasks and duties encompassed by wastewater disposal planning are definitively regulated by the Federal Water Resources Act, and with regard to environmental protection are principally intended to protect water bodies.

wastewater disposal plant

Wastewater disposal plants include any installation dedicated to wastewater disposal, and in particular to the collection, forwarding, treatment, discharging, percolation, spraying and irrigation of wastewater, as well as the dewatering of sewage sludge in the context of wastewater disposal. The establishment and operation of wastewater disposal plants must correspond to 'state of the art' and must also comply with the usage conditions and constraints relating to the discharge of wastewater (Articles 4 and 5 WHG, old version). This especially includes technical provisions for the construction, operation and maintenance of wastewater disposal plants. If existing plants do not meet these standards, the *Länder* must ensure that the necessary measures are carried out (Article 18b para. 2 in conjunction with Article 7a para. 3 WHG, old version).

wastewater fungus

Thread-like fungi, but in the broader sense also filamentous bacteria which occur in large quantities in wastewater that is rich in carbohydrates. As a result of forming floating masses, these sewage fungi can block filters and/or contribute to sludge accumulation.

Wastewater Ordinance

Abwasserverordnung (AbwV): A federal ordinance that stipulates the minimum requirements for the discharge of wastewater into a water body; the minimum requirements are established by taking into account the origin of the wastewater. Substance-related stipulations are sector-specific; Appendix 1 establishes the requirements for domestic and municipal wastewater. It replaces the earlier Wastewater Discharge Ordinance and the Wastewater Origin Ordinance.

wastewater percolation

The manner in which suitably treated wastewater is introduced into subsoil with no agricultural usage, e. g. via a percolation system, seepage pits, or a seepage pipe.

From a technical perspective, this is achieved in percolation facilities.

Source: DIN EN 1085

wastewater plant

1 A facility in which wastewater is treated physically, biologically and/or chemically.

Source: DIN EN 1085

2 A facility for the purification of municipal, commercial or industrial wastewater.

wastewater production

The daily total of wastewater discharge in relation to the number of inhabitants.

wastewater purification

1 A generic term for any technique / technology used to reduce wastewater constituents via biological, chemical and/or mechanical processes.

2 Municipal wastewater and wastewater from many industrial sectors which generally and principally contains organic wastewater constituents must currently (as a bare minimum) be treated in a completely organic way. If the wastewater is particularly polluted or discharged into inefficient water bodies or lakes, completely organic processes on their own will not be sufficient. Wastewater must then be subjected to further treatment (in 'advanced wastewater purification' facilities).

wastewater purification plant

A facility that allows the purification of wastewater, possibly in conjunction with other types of wastewater treatment, e. g. cooling or neutralisation. See: wastewater plant.

Source: DIN 4045

wastewater purification technology

A generic term for technologies used to purify wastewater. Municipal wastewater and wastewater from many industrial sectors which generally and principally contains organic wastewater constituents must currently (as a bare minimum) be treated in a completely organic way. If the wastewater is particularly polluted or discharged into inefficient water bodies or lakes, completely organic processes on their own will not be sufficient. Wastewater must then be treated in 'advanced wastewater purification' facilities.

wastewater sprinkling

1 Unlike broad irrigation, the primary purpose of sprinkling is to purify wastewater, whereby the soil is used as a mechanical and biological purification medium.

2 The agricultural utilisation of wastewater. If a sufficient gradient is present, the wastewater emerges from the head ditch and onto the irrigation field, and trickles downhill to lower-lying drainage ditches. If the gradient is insufficient, it reaches the irrigation field and moves into furrows in which it percolates.

wastewater type

1 Depending on its origin, wastewater is divided into:

- Domestic wastewater
- Industrial and commercial wastewater
- Cooling water

2 With regard to the division into partial flows (sanitation concepts, domestic wastewater), a distinction is made between:

- Grey water (washing water)
- Yellow water (urine only)
- Brown water (faeces only)
- Black water (urine and faeces)
- White water (runoff)

wastewater treatment

Deliberately altering the composition of wastewater as a result of, for example, purification, cooling, neutralisation.

Source: DIN 1045

wastewater treatment plant

See: wastewater purification plant

wastewater volume

The quantity of wastewater produced over a certain period of time by a private household, community or business, indicated in unit of volume per unit of time (e. g. l/s, m^3/h).

Source: Lexikon der Abwassertechnik, 7th Edition

watercourses

1 Surface water bodies with constantly or intermittently flowing water. *Please note: This is a generic term for streams, rivers, canals, etc.*

2 Natural or artificial (onshore) surface water bodies flowing constantly or intermittently within a channel.

water bloom

The greatly increased growth of algae in water bodies, caused by eutrophication; the mass development of blue algae, diatoms, green algae, etc. in a natural water body. It arises as the result of a previous discharge of wastewater and the large quantities of inorganic plant nutrients (such as nitrate, sulphate and phosphate) formed and drained off during biological purification and the accompanying mineralisation of organic pollutants. This is also promoted by high temperatures and above-average light irradiation. The effluents of some types of algae are particularly toxic to fish. Water bloom can adversely affect the ability to use a water body to obtain drinking water, or as bathing water.

water body

As specified by DIN 4049, 'water body' is the designation for any water that is flowing or standing in nature. It is associated with the water cycle, including channels and aquifers.

water-harming substances

Solid, liquid and gaseous substances which are capable of negatively altering the physical, chemical or biological composition of water. They include: acids and bases; alkaline metals; silicon alloys; organic metallic compounds; halogens and acid halogenides; metallic carbonyles and corrosive salts; mineral and tar oils and their derivatives; liquid and water-soluble hydrocarbons; alcohols; aldehydes; ketones; esters, organic compounds containing halogen, nitrogen and sulphur; toxins.

Source: Article 19g WHG, old version (Version dated 19.08.2002)

water law

The legal provisions relating to water protection, water usage, watering and dewatering, plus any other law or provision affecting water.

water management

Any measure intended to avoid an adverse change to the ecological and chemical status of a water body, as well as to conserve and recreate a good ecological and chemical status for the water body (Article 25a WHG, old version).

water pollution

1 Impacts on a water body as a result of adverse factors which can be of geogenic, biogenic or anthropogenic origin. Excessive water pollution can damage the water body.

Source: DIN 4049 Section 2

2 Impacts on a water body which adversely affect the natural physical, chemical and biological properties of the water body. When it comes to anthropogenic pressures, a distinction is made between material pressures (nutrient and pollutant inputs from point and diffuse sources) and non-material pressures (hydraulic and morphological pressures together with quantitative pressures resulting from water extraction).

water pollution control

Encompasses any measure intended to avoid the pollution of natural water bodies (precautionary principle) and to conserve the capacity for natural self-purification (See: water protection).

water quality class

Classification of the biological / ecological quality of a water body by the *Länderarbeitsgemeinschaft Wasser* (LAWA) in seven stages (four quality classes and three intermediate stages are differentiated):

- I = no or very little pollution
- I-II = slight pollution
- II = moderate pollution
- II-III = critical pollution
- III = heavy pollution
- III-IV = very heavy pollution
- IV = excessive pollution

'Quality Class V = ecologically destroyed' was introduced in 1990 as an additional indicator of sections of water bodies whose pollution has reached such a level that the biological equilibrium has been destroyed.

water quality model

A simplified, idealised mathematical description of the local and temporal physical, chemical and biological processes occurring in water bodies, and their correlation.

Source: Lexikon der Abwassertechnik, 7th Edition

water usage

1 Water bodies are part of the ecosystem. They also provide numerous anthropogenic usages which can be summarised in the form of the following usage classes:

- Extraction from water bodies
- Discharges into water bodies
- Energy production
- Inland navigation
- Professional fisheries
- Leisure and recreation

2 The most important types of water body usage include: the supply of drinking water; the supply of process water, including the extraction of cooling water; fishing; navigation; the utilisation of water power; agricultural usage; usage for leisure, recreation and health purposes; usage as a receiving water for wastewater, including cooling water processes. The different types of usage often lead to major conflicts of interest since, for example, the simultaneous usage of a water body as a receiving water for wastewater can exclude usage as bathing water.

WW 54 - Index