57. Timber, sawmills, wood processing and wood products

Contents - Previous - Next

Contents

1. Scope

Wood is man's oldest **material** and **energy source**; it is particularly important as it is a **renewable resource**. Despite the availability of metal, synthetic (plastic/ chemical) and mineral materials it is still important as a raw material. Because of their technological properties, tropical woods have been accepted - particularly in the last thirty years - as valuable functional and decorative materials. In most tropical and subtropical countries, wood still plays a vital role as an energy source.

The major timber sub-sectors are as follows:

- production (timber industry, incl. reforestation), felling and transport
- mechanical woodworking (sawing, shaping, milling, sanding)
- manufacture of wood board materials (plywood, chipboard and fibreboard)
- transformation into other products with extensive chemical modification of timber
- combustion.

This article focuses mainly on the primary, i.e. **mechanical processing** of wood, the manufacture of wood products and charcoal production, with only a brief look at combustion.

The **manufacture of paper and pulps** from wood is regarded as a separate, secondary processing sector and is not covered by this brief but by the environmental brief Pulp and Paper.

The environmental impacts of woodworking and wood processing operations, in the form of dust, noise and odours, can be countered to a large extent by appropriate **siting**, namely downwind from residential areas (see also the environmental brief Planning of Locations for Trade and Industry). The problem of **wastewater**, on the other hand, calls for closer attention. Direct effects on personnel can be at least reduced by the wearing of suitable **hearing protection and breathing equipment**.

In terms of the **scale of environmental impacts** it should be borne in mind that advancing **slash and burn**

(shifting cultivation) can be the most dangerous environmental impact of timber felling, and is frequently the most significant factor in forest destruction.

The major effect on employment to be considered is that the workforce in the timber industry is almost exclusively male.

2. Environmental impacts and protective measures

2.1 Mechanical woodworking

Wood is a raw material which regrows and is obtained mainly from **natural woodland**, with **plantations** still playing only a minor role in many countries.

The dual system of national forestry authorities and private timber concessionaries often results in a clash of business management and forestry policy interests - being founded largely on conflicting principles.

Woodworking *per se* begins in the sawmill with debarking, unless this has already been done in the forest, followed by the cutting into lengths and cutting to size of timber supplied from the forest. The cut timber is either used **directly as building lumber** or is **upgraded** by shaping, milling, sanding and painting or impregnation.

Sawmills are workshops in which **round wood** is processed **into sawn lumber** (primary processing). Mechanical woodworking goes hand in hand with noise and dust, and is often carried out in the same mills which carry out **surface treatments** with paint, stains etc., processes which result in the formation of gaseous and substances with strong odours.

Noise

The mechanically driven transport, cutting, milling, shaping and dust extractor installations in the timber industry generate noise, a problem which is exacerbated where sawmills are built to an open design in warmer climates.

However, because most **sites** are selected because they are **close to raw material sources**, they tend to be far from residential areas. Thus it is only mill personnel who are mainly affected. For this reason, the wearing of hearing protection should be compulsory and, where new plant or new equipment is to be installed, emphasis should be placed on providing tooling which is enclosed and designed to reduce noise.

Further negative effects on machine operators exist in the form of **vibrations**. The reduction of vibrations is an important factor when laying the foundations and erecting operating and control stations.

Dust emissions

Alongside noise, dust is emitted from mechanical woodworking processes. In **sawmills**, wood cutting produces wood shavings, but because the wood is in most cases supplied fresh from the forest or is fibre-saturated, dust emissions do not present **a major problem in relative terms**, and fabric filters or wet extractors are not generally required. However, where wood shavings are stored in the open air, measures must be taken to protect against airborne dust.

Far more significant is the dust generated by mechanical woodworking in **joinery works, cabinet-making and similar businesses**, where both dust quantity and qualitative dust composition differ from that in a sawmill. The crucial factor is the **fineness** of the dust, expressed by its grain size and grain size distribution. Fine dust is naturally more difficult to remove than coarse dust and constitutes a **greater health hazard** to man, particularly where the particles are small enough to reach the lungs. The fine dust content is particularly high in sanding operations, and not so high in operations which produce shavings.

The **inhalation** of wood dust, particularly hardwood dust, can result in the absorption of harmful substances found in wood, which in turn can lead to **serious illnesses**. Thus, before any wood processing is undertaken, the health risks arising from working with wood must be thoroughly investigated and adequate precautions taken.

To reduce the quantity of dust generated at workplaces machines must be fitted with extractor systems, a measure which is justified as both a **health precaution** for employees and a **fire and explosion** prevention measure. Machines must be enclosed whenever possible and the extraction and transportation installations must be designed to handle the quantities of dust produced. If the extractor unit is likely to generate a high partial vacuum in the workroom, a pressure compensation system must be provided, but this must not cause any draughts in the workplace. Even where the industrial building is of an open design, every effort should be made to prevent draughts.

If **harmful substances** are released during the woodworking operations, the **exhaust air** cannot be **returned** to the work areas. Furthermore, where exhaust air is returned, the dust load at the workplace must not exceed permitted levels. The extracted dust must be discharged through non-flammable, fracture and wear-resistant extraction pipes, which must be designed and their rate of extraction dimensioned so that no undesirable deposits are able to form in the system.

Before the exhaust air is discharged into the environment the **dust** it contains must be **separated off**, for which purpose **centrifugal separators or fabric filters** are used. More costly and more effective fabric filters are required where extracted air contains sanding dust. Due to the risks of fire and explosion the extractor installations must be fitted with **preventive safety devices**, such as pressure relief valves, bursting discs, spark detection installations, smouldering fire alarms and fire extinguishing equipment.

Gaseous emissions

When wood is dried, **volatile constituents of wood** in the exhaust air generate **odours**, and this exhaust air must therefore be released so as to avoid any odour nuisance.

Since **wood processing mills** are often sited in **isolated locations**, as already mentioned, the employees are those most subject to gaseous emissions.

This problem can be minimised by an appropriate **choice of site** (in terms of distance, allowance for the prevailing wind direction).

Otherwise, **gaseous emissions** are only of **minor significance** in **sawmills**.

Analysis and evaluation of environmental impacts

In Germany timber mills are governed by the *Technische Anleitung zur Reinhaltung der Luft* ***TA-Luft*** [Technical Instructions on Air Quality Control] and the *Technische Anleitung zum Schutz gegen Lrm* ***TA-Lrm*** [Technical Instructions on Noise Abatement]. Accordingly the TA-Luft of 1986 restricts the **mass concentration of wood dust** in inhalable form to 20 mg/m^3 at a mass flow of 0.5 kg/h. Lower limit values apply correspondingly to various dusts from woods treated with certain wood preservatives.

For most of the **organic substances** involved in wood processing, the upper limit is 150 mg/m^3 at 3 kg/h. For airborne dust, which is a health hazard, concentration values of 0.45 mg/m^3 and 0.30 mg/m^3 are specified.

The acoustic pressure level is taken as the basic unit to describe the **noise situation**. Where measured and assessed values are indicated, three fundamentally different frequency weighting curves are used: single measured value, effective level and evaluation level (German DIN standards, guidelines of the Association of German Engineers VDI). In Germany the permissible **limit values** are 35 and 70 dB(A), depending on the preconditions for assessment.

In the case of **wood preservatives** their composition must be carefully examined (preservatives containing PCB's are banned in Germany). They must be kept sealed and accident-proof during storage. No wood preservatives dripping from treated timber are allowed to seep away in an uncontrolled fashion. Appropriate fire and accident prevention measures must be taken and **waste** must be disposed of correctly.

Where sawmills or mechanical woodworking mills are to be built or re-equipped, these statutory provisions must be applied as guidelines where there are no national regulations.

Interaction with other sectors

The sawmill industry generally obtains its raw products from nearby forests. It must be ensured that the timber comes only from a **properly managed forest** (management strategy, coordination of individual usage plans, yield regulation, forestry and wood crop techniques) operating on the principle of **sustainability**.

Sawmills supply their products primarily to the **wood-processing trade and industry** (building, furniture and packaging sectors) and also for export. On the other hand the **waste material** produced contributes to **supplying** the derived wood product industry, particularly the chipboard industry, with **raw materials**.

The **burning of waste wood** concerns all aspects of timber usage and is therefore considered in a separate section.

Mechanical woodworking is primarily associated with **the generation of noise and dust**, with **gaseous emissions** and **odours** occurring only to a limited extent during artificial drying or treatment, and merely constituting a nuisance. Generally speaking, the sawmill industry does not damage or endanger the environment, except where **wood preservatives** are used, but even this problem can be avoided by careful **siting** of mills relative to residential areas.

2.2 Derived wood product manufacture

The term "derived wood products" covers **chipboard, fibreboard and plywood**. In addition to wood, these products - with the exception of a few types of fibreboard - contain an organic or inorganic **bonding agent** and in some cases **additives**.

The **bonding agents** used are mainly amino and phenolic resins, condensation products from an amino compound (urea, melamine) or a phenolic substance (phenol, resorcin, cresol or formaldehyde). Chipboard bonding agents on a diisocyanate adhesive base are a relatively new development. Polyvinyl acetate adhesives are used for **wood core plywood**.

Chipboard manufacture

Practically all varieties of wood, wood waste and in some cases fibrous plant substances, bark and biomasses can be used as the feedstock for board. The first stage in the process is the **machining of the raw material**. Long cut or round wood is either cut into chips with drum chopping machines or processed directly into shavings with cutters. The next stage in shaving processing is **drying**, following by **sizing, intermediate storage, bonding and hot pressing** of the cut material. The initial production stages take place in enclosed installations without any significant **emissions**, these occurring only at the stage of hot bonding in the chipboard press at temperatures of 160 to 220C. The final production stages comprise trimming, sanding and formatting of the board.

The main bonding agents used are amino and phenolic resins, condensation products from an amino compound (urea, melamine) or a phenolic substance (phenol, resorcin, cresol or formaldehyde). Chipboard bonding agents on a diisocyanate adhesive base are a relatively new development. Polyvinyl acetate adhesives are used for **wood core plywood**.

Plywood manufacture

The term "plywood" covers **veneer plywood** and **wood core plywood**, the latter containing a central layer of rods, while veneer plywood is made by bonding together a number of individual sheets of veneer.

Suitable untreated wood is cut into veneer by sawing, cutting or scraping, dried and then bonded and pressed. The final production stage comprises trimming, sanding and formatting.

Fibreboard production

A distinction is made between soft fibreboard, medium-density fibreboard (MDF) and hardboard.

Soft fibreboard contains no bonding agents. **Hardboard** likewise contains no adhesive, or at the most very small quantities of a phenol-formaldehyde bonding resin. **MDF**, like chipboard, contains 7 to 9% bonding agent.

The first stage of fibreboard production involves the production of fibres from wood, a process carried out by **heat or chemical treatment**.

It is then pressed by a number of different processes.

Manufacture of mineral-bonded derived wood products

These products are made from **wood chips, wood shavings or wood fibres** and a **mineral bonding agent** such as cement, gypsum or magnesite. Wood is the main component, accounting for at least 85% of the dry weight. Manufacture is similar to that for chipboard, except that drying and hot pressing are not required.

3. Notes on the analysis and evaluation of environmental impacts

Noise emissions are produced in wood transport, cutting and preparation in all four manufacturing processes.

Dust emissions may arise in stores. As in sawmills the resultant nuisance can be reduced by a sensible choice of site and by providing suitable precautions for employees (enclosed workstations, personal hearing protection).

Extremely **fine dust** is produced in the final stages of chipboard, plywood and fibreboard manufacture and this must be removed by means of centrifugal separators or fabric filters, as it is a health hazard to employees.

Gaseous emissions are produced only in the drying of wood shavings and the pressing of shavings and veneers.

In chipboard and plywood pressing, where amino bonding resins are used, **formaldehyde** is the main substance yielded in terms of the mol ratio of the bonding resin. Where phenol-formaldehyde bonding resins are used, only traces of **phenol** are found, and smaller quantities of formaldehyde are produced than is the case with amino bonding resins. **Phenol** and **formaldehyde** are both **potential health hazards**. In Germany formaldehyde emissions at the workplace must not exceed 0.6 mg/m^3 and the finished board formaldehyde content must not exceed 10mg/100g board weight, according to EC Directives. After **fitting the** boards formaldehyde concentration must not exceed 0.1 ppm in the ambient room atmosphere.

The Gefahrstoffverordnung [Ordinance on Hazardous Substances] of 1986 specifies the formaldehyde emission values for all derived wood products in Germany. These gaseous immissions do not occur during the manufacture of mineral- bonded derived wood products.

Wastewater problems occur during the cleaning of the bonding machines and presses. In fibreboard manufacture, wastewater is produced during the wet process and contains **wood particles, wood substances, bonding agents** and other **treatment agents** which can be cleaned using physical processes (sedimentation, flotation or filtration) and/or biological processes. Semi-dry and dry processes do not produce any wastewater.

Residues in the form of wood particles can be returned to the production process in chipboard manufacture, but are otherwise burnt.

In addition to the specific statements in the text, the information relating to mechanical woodworking is also applicable to the **analysis and evaluation of environmental impacts**.

4. Interaction with other sectors

The wood product industry is reliant upon the **forest** as its raw material supplier, except where wood waste can be used, as is the case in the chipboard and fibreboard industry. The basic tenet here is that of the principle of sustained yield. The environmental brief **Forestry** contains detailed information on this subject.

Round wood can be fully utilised by linking sawmills wherever possible to fibreboard and chipboard manufacture.

Derived wood product factories are major **power consumers** which today generate their power with wood very rarely nowadays. The environmental briefs **Overall Energy Planning, Thermal Power Stations and Renewable Sources of Energy** should be consulted in this regard.

Wastewater management issues are also addressed in a separate environmental brief.

Charcoal production

Charcoal is produced by the **thermal decomposition** of wood carried out **without air** (wood pyrolysis). This process also yields **gaseous and liquid reaction products** such as wood gas, wood vinegar, wood spirit and wood tar.

Charcoal is produced at temperatures of between 400 and 600C, and is used as a **fuel**, a **reducing agent** in metallurgy and as a **raw material** for the chemical and pharmaceutical industries. Wood tar and the other liquid organic substances can be processed or alternatively burnt as an energy source.

Charcoal production is the only process still used today on an industrial scale in which wood is **chemically modified** to a substantial degree. Charcoal production is not therefore classified as part of the timber industry, but constitutes a separate **sector of the chemical industry**.

In many countries charcoal is an important **source of energy** for cooking and heating. The favourable ratio of weight to calorific value means that it can also be **transported considerable distances** from the place of production to its market. This fuel is in particular demand in cities because it produces heat without a great deal of smoke.

Charcoal is often produced in **small businesses** (with the exception of the East Amazon, Caracas), which either fell the raw material themselves or have charcoal production plants for **wood waste** in the immediate vicinity of sawmills. The latter arrangement is particularly useful where there is no derived wood product plant downline from the sawmill.

Gaseous emissions from charcoal production, in the form of smoke and strong odours do not merely constitute a nuisance: where the process is inefficiently managed pyrolysis derivatives, such as benzpyrene may constitute a **health hazard** to employees, and at high concentrations also to the general population (**cancer risk**). The comments made on the siting of sawmills apply here too.

The charcoal production process yields considerable quantities of **pyrolysis water** - up to 15% of the feedstock; this wastewater contains, *inter alia*, pyrolysis tar and water-soluble organic substances. Whereas liquid pyrolysis products must be **conditioned** according to the regulations for chemical industry installations in **charcoal production** on an industrial scale, **no such solution yet** exists **for the small business**.

If large-scale charcoal production from wood waste is sited close to wood processing mills appropriate measures must be taken to prevent pollutants from penetrating the water or soil.

Burning of wood waste

The quantity of residual material (sawdust, splinters, bark, pieces) varies from process to process and product to product; tropical hardwood cutting produces extremely large quantities of waste (up to 60%). **Waste disposal** may take the form of combustion **for energy production**, as it is not possible to market the wood waste elsewhere because of the siting of the mill close to the saw of supply of the raw material. The presence of a **downstream pulp or paper mill** is a rare exception.

Complete incineration produces carbon monoxide, organic hydrocarbons, tar and soot. It is **almost impossible to influence** the **nitric oxide emissions** from wood furnaces.

5. Summary assessment of environmental relevance

While plywood mills process high-quality round timber, chipboard and fibreboard are the result of the value-adding utilisation of different wood varieties, some of which are low grade.

Gaseous emissions represent **further** harmful environmental impacts of chipboard and fibreboard plants, the main principal hazardous substance being **formaldehyde**. By contract, bonding with phenolic resins and diisocyanates help reduce emission values. One exception, in terms of emissions, is the manufacture of adhesive-free fibreboard.

Gaseous emissions from **wood shaving driers** have few environmentally harmful properties, especially in the case of hardwood, although the **intensity of the odours** produced constitutes a nuisance. The same **siting** criteria apply as for sawmills.

6. References

Anonymous 1976: Planung von Absaug- und Entstaubungsanlagen; Internationaler Holzmarkt 67, Heft 24, p.1...6.

ASP; without year of publication: Arbeitzsmedizin - Sozialmedizin - Prventivmedizin; ASP-Hefte 4, 7, 10; Gentner Verlag Stuttgart.

Baldwin, S.; Geller, H.; Dutt, G.; Ravindranath; N.H.; 1985: Improved Woodburning cookstoves: signs of success; Ambio; 14; 4/5; 280-287; 1985, 47 ref.

Baller, Gerd; 1987: Lrmschutz im Tischlerhandwerk; dds; No. 5; p.115; No. 6, p.67.

Baller, Gerd; 1987: Staub- und Spneabsaugung im Tischlerhandwerk; No. 8, p.47; No. 9, p.65.

Baums, M.; Brtzmann, U.; 1986: Die Gefahrstoffverordnung ist in Kraft getreten; Kommentar und Hinweise fr die holz- und kunstoffverarbeitende Industrie; Holz-Zentralblatt 112 (1986), p.1833...1841.

Bernert, J.; 1976: Emissionen von Holzspanplattenwerken, Wasser, Luft, Betrieb 20, p.27...34.

Birjukov, V.; Oskov, N.; Zamaraev, M.; Sokolov, V.: Vervollkommnung der Verfahren zur Beseitigung schdlicher Emissionen holzverarbeitender Betriebe; Holztechnologie 18, p.235...238.

Blanchet, G.; 1984: Beehive charcoal kiln in Zaire; Bioenergy 84 Proceedings of conference 15-21 June 1984, Gothenburg, Sweden, Volume III, Biomass conversion (edited by Egneus, H; Ellegard, A) 160-162; 1984.

Bringezu, St.; 1988: Zur Prfung und Bewertung der Umweltvertrglichkeit von Holzschutzmitteln. Holzschutz und

Umweltschutz haben gemeinsame Ziele; als Roh- und Werkstoff, 1989; p.421 ff.

Brocksiepe, G.; 1971: Holzverkohlung; in Chemische Technologie Band 3; p.417...492; Carl Hanser Verlag, Munich.

Brocksiepe, G.; 1976: Holzverkohlung; in Ullmanns Enzyklopdie der Technischen Chemie Band 12, p.703...708; Verlag Chemie Weinheim.

Bundesgesundheitsamt [German Federal Health Office], without year of publication: Vom Umgang mit Holzschutzmitteln; eine Informationsschrift vom BGA; own publication Berlin.

Busch, B.; Energiegewinnung aus Rinde; Holz-Zentralblatt 107, p.351...352.

Buslei, Wilfried; 1989: Holzstaub, Verdacht auf Krebs; dds; No. 9, p.44; No. 10 p.70; No. 11 p.54; No. 12 p.96.

CRIR; 1985: Forest Product Research International - Achievements and the Future; Carbon from Biomass - Woodgas in Practice; Proceedings Volume Five; own publication Pretoria/RSA.

Deppe, H.-J., Ernst, K.; 1990: Taschenbuch der Spanplattentechnik, 3. Auflage edition, 1990; DRW-Verlag Stuttgart.

DRW 1970: Maschinen und Maschinenstraen in der Holzindustrie; DRW-Verlag Stuttgart.

Ernst, K.; 1987: Umweltfreundliche Holzwerkstoffe; Holz als Roh- und Werkstoff, 1987; p.411.

Ernst, K.; Schwab, E. Wilke, K-D.: Holzwerkstoffe im Bauwesen Teil 1: Materialkunde; EGH Entwicklungsgemeinschaft Holzbau; own publication, Munich.

Ferreira, F.A.; Alfenas, A.C.; 1985: Injurias em folhas de Eucalyptus spp. causados por condensados pirolenhosos originiarios de fornos de carvoejamento; Foliar injury in Eucalyptus spp. caused by condensed pyrolignins from charcoal kilns; Revista arvore; 9; 2; 186-190; 1985; 7 ref.

Graf, E. 1989: kologische Aspekte zur chemischen Holzbekmpfung; Holz als Roh- und Werkstoff, 1989; p.383 ff.

Hartmann, E.; Havla, R., 1984: Technologie und Technik der energetischen Nutzung von Holzresten unter besonderer Bercksichtigung der Wrmegewinnung durch Verbrennung; VEB Wissenschaftlich-Technisches Zentrum der holzverarbeitenden Industrie; own publication: Dresden.

HII, G.S.C.; Tay S.S.; 1980: An assessment of sawmill pollution in Sarawak; Malaysian Forester; 43; 2; 238-243; 1980; 5 ref.

Kauppinen, T.; Lindroos, L.; Mkinen, R., 1984: Holzstaub in der Luft von Sgewerken und Sperrholzfabriken; Staub-Reinhaltung der Luft 44, p.322...324.

Knigge, W.; Schulz, H., 1966: Grundriss der Forstbenutzung; Entstehung der Eigenschaften, Verwertung und Verwendung des Holzes und anderer Forstprodukte; Verlag Paul Parey: Hamburg/Berlin.

Koch, D.; Funke, T.; Grosse Wiesmann, G.; Wiemer, H-J.; Wllenweber, H-J.; 1985: Werkstoffe und Gefhrdungen im Tischlerhandwerk; Schriftenreihe der Bundesanstalt fr Arbeitsschutz; Forschungsbericht Nr. 441; Wirtschaftsverlag NW: Bremerhaven.

Knig, E.; 1972: Holz-Lexikon, Bd. 1 und Bd. 2; DRW-Verlag Stuttgart.

Kollmann F. 1951: Technologie des Holzes und der Holzwerkstoffe Bd. 1 und Bd. 2; Springer-Verlag.

Lemann, M.; 1981: Abgasreinigung mit Wrmerckgewinnung; Holz-Zentralblatt 107, p.41...42.

Lingelbach, K.; 1982: Manahmen zur Senkung von staub- und gasfrmigen Luftverunreinigungen an einem Spanplattenwerk; Bericht 50 441-3/8 des TV Kassel; Umweltbundesamt [German Federal Environmental Agency]: Berlin.

Lorenz, W.; 1982: Heizen mit Holz; Technik am Bau 2/82, p.117...121.

Maier, G.; 1988: Spneabsaugung an Maschinen. berlegungen zu Strmungstechnik und Konstruktion; Holz als Roh- und Werkstoff 1988; p.311.

Mamit, J.D.; Wee, H.B.; Lai, C.J.; 1985: The survey of the disposal of woodwaste by sawmills in Sarawak; Technical Report (Timber Research and Technical Training Centre); Sarawak; No. TR/4; 15pp.; 1985; 3 ref.

Marutzky, R. 1977: Untersuchungen zum Terpengehalt der Trocknungsgase von Holzspantrocknern; Holz als Roh- und Werkstoff 36, p.407...411.

Marutzky, R.; Mehlhorn, L.; May, H.-A.; 1980: Formaldehydemissionen beim Herstellungsproze von Holzspanplatten; Holz als Roh- und Werkstoff 38, p.329...335.

Marutzky, R.; 1981: Emissionstechnische Erfassung von luftverunreinigenden Stoffen aus Anlagen zur Herstellung von Holzspan- und Holzfaserplatten; Gesundheitsingenieur - Haustechnik - Bauphysik - Umwelttechnik - 102, p.300-335.

Marutzky, R.; 1981: Mglichkeiten zur Verkohlung und Vergasung von Holz und anderen pflanzlichen Reststoffen; Holz-Zentralblatt 107, p.315...317.

Marutzky, R.; 1984: Holzreststoffverbrennung - Techniken, Umweltschutzmanahmen, Wirtschaftlichkeit; Holz-Zentralblatt 110, p.1693...1694 and 1713...1714.

Marutzky, R.; 1987: Grenzen der Emissionsminderung bei Holzspnetrocknern unter Bercksichtigung der neuen TA-Luft; Holz als Roh- und Werkstoff 1987; p.421.

Marutzky, R.; Flentge, A.; Mehlhorn, L; 1987: Zur Messung der Formaldehydabgabe von Holzwerkstoffen, Baustoffen und Mbeln mittels der $1m^3$ Methode-Kammer Methode; Holz als Roh- und Werkstoff, 1987; p.339.

May, H.-A.; Mehlhorn, L.; Marutzky, R.; 1981: Gefahrlose Spnetrocknung bei der Spanplattenfertigung; Schriftenreihe "Humanisierung des Arbeitslebens" Bd.21; VDI Verlag Dsseldorf.

Mayrhofer; W; Pimminger, M; Gritzner, G; 1987: Untersuchungen zur Abgasreinigung von Spnetrocknern; Holz als Roh- und Werkstoff, 1987; p.379 ff.

Nantke, H-J.; 1986: TA-Luft - Was ist bei der Spanplattenherstellung zu beachten? Holz-Zentralblatt 112, p.2183.

Nimz, H.H.; 1988: Probleme, Kentnisse und Hoffnungen zum Thema "Holzstaub"; Holz als Roh- und Werkstoff 1988; p.117 ff.

Patao, D.N.; 1987: Sample Survey of charcoal and fuelwood consumption in Region 1; FPRDI, Vol. 16, No. 1, Jan-June 1987; p.58 ff.

Peters, F.; 1983: Energieerzeugung aus Holzreststoffen; Industriefeuerung 25, p.49...58.

Philipp, W.; 1980: Verbrennung von Rinde und deren Abwrmenutzung; Holz-Zentralblatt 106, p.1457...1458.

Robertson, D. (Ed); 1983: The Sixth International FPRS Industrial Wood Energy Forum 82, Volume II: Power and Heat Plants; Forest Products Research Society: Madison, WI/USA.

Robertson, D. (Ed.); 1983: The Sixth International FPRS Industrial Wood Energy Forum 82, Volume II: Gas and

Charcoal Production from Wood/Biomass Fuels; Forest Products Research Society: Madison, WI/USA.

Rong, M; 1981: Herstellung von Holzspan- und Holzfaserplatten -Verfahrenstechnik und Emissionen luftfremder Stoffe; Gesundheits-Ingenieur - Haustechnik - Bauphysik - Umwelttechnik 102, p.287...295.

Saeman, J. (Ed.); 1976: Wood Residue as an Energy Source; Forest Products Research Society: Madison, WI/USA.

Salje, E. (Ed.); 1975: Umweltschutz bei der Holzbearbeitung; Tagesbericht; Deutsche Messe- und Ausstellungs-AG: Hannover.

Salje, E.; Geerken, J. 1988: Verringerung der Staubemissionen beim Frsen; Holz als Roh- und Werkstoff, 1988; p.340 ff.

Schlotterhausen, R; 1986: Holzwerkstoffe - Merkmale und Verarbeitung; Wedra Verlagsgesellschaft: Stuttgart.

Wolf, Dr. J; without year of publication: Sicherheitswissenschaftliche Monographien Gesellschaft fr Sicherheitswissenschaft; Bergische Universitt Wuppertal, Wirtschaftsverlag NW GmbH.

Soine, H.; 1982: Energiegewinnung aus Holzabfllen; Holz als Roh- und Werkstoff 40, p.217...222, 263...268 and 281...286.

Smith, K.R.; 1986: Biomass combustion and indoor air pollution: the bright and dark sides of small is beautiful; Environmental Management; 10; 1; 61 to 74; 1986; 52 ref. BLL.

Strehler, A.: Wrmegewinnung aus Hackschnitzeln und Scheitholz; Holz-Zentralblatt 110, p.292...294.

Tsai, C.M.; 1983: Study on the quality improvement of urea-formaldehyde resin bonded plywood; Memoirs of the College of Agriculture, National Taiwan University; 23; 2; 80-82; 1983.

Tsai, C.M.; 1984: Effect of adding urea or melamine to urea-formaldehyde resin on the elimination of formaldehyde release from plywood; Technical Bulletin, Experimental Forest, National Taiwan University; No. 155; 14pp.; 1984; 65 ref.

VDMA 1986: Holzfeuerungsanlagen - Emissionsvorschriften, Holzbrennstoffgruppen; Einheitsblatt 24178 Teil 1; Verband Deutscher Maschinen- und Anlagen- bau e.V./Frankfurt.

VKE 1985: PVC - Ursache fr Dioxin-Bildung? Informationsschrift des Verbands Kunstofferzeugende Industrie/Frankfurt.

United Nations Industrial Development Organisation; 1983: wood processing industry; Sectoral Studies Series, Division for Industrial Studies, United Nations Industrial Development Organisation; No. 4; 83 pp.; 1983; 59 ref. UNIDO/IS. 394, Limited distribution.

Vorreiter, L. 1958: Holztechnologisches Handbuch, Bd. I und II.; Verlag Georg Fromme: Vienna/Munich.

Contents - **Previous** - **Next**

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

---

58. Pulp and paper

Contents - **Previous** - **Next**

Contents

1. Scope

1.1 Introduction/general information/terminology

Pulp

- **Pulp** (in the context of this brief) is **the common** name for **vegetable cellulose** in the form of fibres or bundles of fibres, more or less free of residual plant parts.

Cellulose is the principal **supporting component** of all **plants** and thus in theory, pulp can be obtained from any type of plant. However, as the various **fibre properties** and also the **fibre content** can **differ widely**, in practice only **relatively few types of plant** are used for **pulp production**.

- Wood is the chief **raw material** used in pulp production. Generally speaking, softwood has longer fibres and hardwood shorter ones.
- In addition to wood, **annual plants** are used for pulp production, mainly in countries with

scarce wood resources (China, India etc.).

- Pulp is produced for **mechanical processing into board, paper etc.** and for **chemical processing to films, synthetic fibres etc.**
- Pulp is produced from the stated raw materials by means of **chemical, chemical-mechanical or mechanical processes**.
- Pulp can also be obtained from **waste paper** (recycling) although in this case it can only be used for paper and board production.
- The **auxiliary materials** used are water, steam, mechanical and electric energy and chemicals.
- **By-products and waste** are produced which can cause direct or indirect atmospheric and water pollution, but which can be **reduced** by **measures within the production plant** (internal means) and by installations downstream from them (external means).

Paper and board

- In the context of this brief, **paper** is a **thin fibrous mat made** principally from **pulp**, with or without surface treatment, manufactured from the above-mentioned types of cellulose.
- **Board** is thick (stiff) paper.
- **Cardboard** is strong board (thickness), made by a special process.
- Depending on the **type of pulp** or **waste paper** and how they are **pretreated**, the properties of the paper, board or cardboard can be adapted for their intended uses, thus the range of **different paper and board types** is manifold.
- The **wastewater** produced during paper and board manufacture contains **pollutants** which can be removed by appropriate **cleaning processes**.

1.2 Pulp production

Table 1.2 summarises the **basic data on pulp**, such as yield, specific energy consumption, relative consumption of chemicals, relative pollutant quantities and relative environmental pollution. Some **basic terms** are also defined below:

1.2.1 Raw materials

Wood

a) Softwood: Mainly pine, fir and spruce varieties, for pulp with long fibres (high strength).

b) Hardwood: Mainly beech, birch, eucalyptus, poplar, other types and mixtures (medium strength) too, depending on the location.

Annual plants

a) Agricultural by-products: Various types of straw (wheat, rice etc.), bagasse, i.e. sugar cane following extraction (low strength). For special papers: linters, i.e. by-product from the cotton oil industry (high purity and strength).

b) Others: Reed, bamboo, jute, kenaf etc. (less commonly used).

Waste paper

Different grades, sorted into unprinted clippings from paper-processing (e.g. printing) through to mixes from domestic collections.

1.2.2 Products and processes

Apart from the hygiene sector (e.g. for nappies) **pulp** is **not an end product** but an **intermediate product for paper manufacture**, and as chemical conversion pulp, **is the raw material for the chemical industry** (fibres, films, plastics).

Pulp is available in a number of **different** forms, the most important of which are:

Groundwood (Mechanical wood pulp)

Groundwood fibers produced mainly from softwood with a grinding stone and containing practically the same constituents as the original wood, except for some extractives. It provides the highest yield and generally is not bleached or only to a low to medium brightness.

Applications: For mass-produced papers at the lower end of the quality scale. Typically: newsprint, writing and printing paper containing wood, duplex board.

Characteristics: Products are of low strength, they yellow in daylight and are not very resistant to ageing.

The chemicals most frequently used (for bleaching): sodium dithionite, peroxides - peroxide being the least polluting bleach.

Plant sizes: 50 - 600 t/day.

TMP - thermomechanical pulp

Comparable with groundwood, but defiberation between rotating discs. Slightly lower yield but better strength properties. Is bleached like groundwood.

Applications: as for groundwood.

Characteristics: as for groundwood.
Plant sizes: 300 - 600 t/day.

CTMP - chemi-thermomechanical pulp (includes APMP)

In contrast to TMP, pulping is facilitated by a chemical pretreatment. The yield is slightly lower, but despite this the mechanical properties of the fibres are improved. Is usually bleached to medium or high brightness.

Applications: As absorbent in the field of hygiene products (nappies etc.), for mass produced printing and writing paper midway along the quality scale.

Characteristics: Depending on the raw material, products are medium to low strength; they yellow quite readily and are not particularly age-resistant.

SC (or NSSC) - semichemical pulp

Still contains considerable quantities of non-cellulose substances. Wood chips or other fibrous raw materials are pretreated with chemicals in pressure vessels and with steam under pressure. Pulping is then carried out in refiners with a relatively low power consumption. Is not usually bleached.

Applications: Packaging papers, particularly corrugated medium in corrugated board.

Characteristics: Produces fairly stiff paper and board, depending on the raw material used.

Chemicals most often used: sodium sulphite, sodium hydroxide and/or sodium carbonate. Recycling or disposal within the mill is necessary.

Plant sizes: 50 - 500 t/day.

Chemically produced pulp

Contains only low to very low quantities of non-cellulosic substances, low yields due to the removal non-cellulosic materials. Wood chips or other fibrous raw materials are pulped with chemicals and steam under pressure. This is usually followed by bleaching and then either drying and pressing into bales as commercial pulp or, in an integrated plant, further processing into paper products.

Applications:

- Unbleached: mostly as packaging paper, also added to lower strength pulps (reinforcing).
- Bleached: mostly for writing and printing papers, also as an additive to lower strength pulps, cellulose for chemical feedstock (dissolving pulp), mostly produced from hardwood.

Characteristics: High strength in the case of softwood products. Bleached substances yellow only slightly and are highly age resistant. High purity for chemical raw materials.

Pulping chemicals: Sodium hydroxide, Na_2S (alkaline processes: "soda", "sulphate") and Ca, Mg, Na and NH_4 bisulphite (acid processes: "sulphite"). Recovery and regeneration of chemicals is a precondition for economic and non-polluting operation. Some of the spent liquor from the sulphite process can be processed by fermentation to form yeast and alcohol or, in its dried form, can be sold as a binding agent.

Bleaching chemicals: Chlorine (the use of which is on the decline), sodium hypochlorite, chlorine dioxide, oxygen, sodium and hydrogen peroxide.

Plant sizes: softwood as raw material: 500 - 1300 t/day; annual plants as raw material: 50 - 250 nnt/day.

Waste paper pulp

Waste paper contains a mixture of pulps from various sources, depending on the composition and sorting of waste paper, and is a substitute for fresh pulp (cheaper, energy-saving). It is pulped mechanically. May be de-inked and bleached following removal of non-paper fibres and other impurities.

Applications: In principle, for all paper and board types, with or without the addition of fresh pulp.

Characteristics: Quality slightly or moderately inferior to fresh pulp, depending on the quality, sorting, cleanliness etc. **Chemicals** for de-inking and bleaching are detergents, fatty acids, dispersants, dithionite, peroxide.

Plant sizes: 50 - 400 t/day.

1.3 Paper and board production

1.3.1 Basic fibrous material, pulp (raw materials for paper and card production)

All the products listed under 1.2.2 are basic materials for the paper industry. In most cases a **mixture** of two or more of them are used to give the paper the **required characteristics** or for **reasons of economy**.

1.3.2 Products and processes

Paper and board types are usually classified into the following **main groups** on the basis of intended use:

- printing and writing (graphic) papers
- industrial papers
- special papers.

Practically all papers and boards are produced on continuously (or in the case of boards sometimes semicontinuously) operating machines, the principle of which is the **dewatering of the aqueous fiber suspension** on a wire to form a fibrous mat which is then **pressed and dried**. The sheet of paper thus produced is packed in the form of **rolls** or **packs of sheets**. The pulp fibres are **pretreated in "beating" machines (refiners)** to give them the **properties required** for the individual type of paper, and **additives** are used to give properties such as ink absorbance, water-resistance, stiffness, colour. **Fillers** such as kaolin (alumina), and more recently calcium carbonate and sulphate improve the **paper surface** for certain printing processes.

The **product groups** are characterised as follows:

Printing and writing (graphic) papers

These **writing and printing papers** are basically subdivided into those containing wood[1] (coated and uncoated)2 and those not containing wood pulp (likewise coated and uncoated), the former mainly as mass-produced papers, the latter for **high quality and special applications**. Today, both kinds contain **increasing quantities (in some cases up to 100%) of waste paper**.

[1] "wood containing": containing not only pure, chemically produced pulp but also groundwood, CMP etc.
"wood free": containing only chemically produced material.
[2] coated: surface treated with dominatingly inorganic pastes.

Industrial papers

These include mainly **packaging papers** and **boards**, comprising many brands of grey common wrapping papers (made from recycled paper) through to high-quality packaging materials for food and luxury goods, in some cases surface treated, multi-layer or coated for costly print processes. **Corrugated board**, made from fresh unbleached pulp or recycled corrugated board (a rising trend) depending on quality, accounts for a **portion** of industrial papers in quantity terms.

Special papers

These cover a wide range of paper types which **cannot** be specifically **allocated** to the two product groups described above, e.g.:

- papers for hygiene applications (tissues, kitchen rolls, toilet paper)
- filter papers for use in industry, the home, the laboratory etc.
- transparent papers for drawing
- photographic papers
- base paper for parchment, vulcanized fibre
- cigarette paper
- capacitor paper etc.

1.4 Secondary and auxiliary installations

Energy supply

Energy is required in the form of **mechanical energy** (electricity) and **heat** (steam). Where no **hydraulic power** is available, electrical energy is obtained either from the **national grid** or generated by a **power plant inside the mill** (steam or gas turbines). **Fossil fuels** (heating oil, natural gas, coal), and also **wood and wood waste** (bark) or other **waste substances** are used for steam production.

The **spent liquor from chemical pulp production** is an important "waste" product in terms of energy. It is burnt in special boilers ("recovery boilers")to produce steam to cover process energy needs.

Water

The **availability of fresh water** is a **basic requirement** for pulp and paper production. The water demand may exceed **150 m^3/t of product**, but in **very modern mills** it may be no more than **2 m^3/t**, although this also depends on the quality of the process management.

Wastewater treatment

Mechanical, biological and/or **chemical wastewater treatment** are now standard in any pulp and/or paper mill.

2. Environmental impacts and protective measures

2.1 Area: Raw and auxiliary materials

2.1.1 Fibrous raw material

Wood

The **afforestation and reforestation** of suitable areas for the raw materials supply of paper and pulp mills are **advantages in terms of climate, water resources and the labour market**.

The use of timber must be planned with a view to maintaining a balance between the **cutting and growth rates**.

Vegetable fiber resources are renewable - in the case of wood by reforestation. **Special measures** are essential for such **single-crop agriculture**; in-depth studies of **cultivation measures** as well as **socio-economic aspects** (e.g. competition for land usage) are essential.

Annual plants

Agricultural products used as raw materials should **not automatically** be regarded **as environmentally advantageous**. For example, if **straw** is not ploughed back into the soil, increased fertiliser use is necessary, whilst the **humus** content in the soil will **drop**. The widespread **burning** of straw is also **undesirable** and the **collection** of straw is relatively **energy intensive** (pressing in bales for transport, yet still bulky, truck capacities by no means fully utilised). Furthermore, the large **stocks** which have to be **held** because of the relatively short harvest period create a **fire risk**.

In the case of **bagasse** (waste from cane sugar production) used as a fibrous raw material for paper, conditions are more favourable in that it does not have to be **collected separately**, but nonetheless **large stocks need to be held** to cover periods when the sugar factory is closed. The **competition between raw material for paper and fuel in the sugar factory** is described in the environmental brief Sugar.

In short, the **use of annual plants** is only **environmentally** positive under **certain conditions**. It is generally **insignificant** and only **relevant in special cases**.

Waste paper

This raw material enables **significant savings** to be made on **energy** compared to fresh pulp, with the exception of fully chemical pulp as modern pulp mills are energy selfsufficent. However, paper **cannot** be recirculated **ad infinitum**. For every circuit there is a **sacrifice in quality** due to fibre damage. However, the **use of waste paper** must be **regarded positively** from the environmental viewpoint, in most of today's cases of application.

2.1.2 Water

Production water (river and well water) is required in relatively **large quantities** (see 1.4 above) and must meet **certain minimum purity criteria**. It must be **processed**, but can be **recycled** in internal circuits a number of times. In less favourable instances the use of wells can result in a **long-term change in the groundwater table**. As far as water requirements are concerned **detailed analyses** with a view to **meeting the needs of competing usages** are essential at the **paper mill** design stage.

2.1.3 Energy

The **environmental impacts** of electricity generation and the use of **fossil fuels**, also used in pulp and paper mills, are known and can be found in the environmental briefs on Thermal Power Stations and Power Transmission and Distribution.

Sector-specific fuels arising in mills during pulp production or in the wood-processing industry are

- spent liquor from the cooking and impregnation process
- bark, sawdust, splinters.

Concentrated spent liquors are burned in recovery boilers specially designed for this purpose, thereby releasing the **pulping chemicals** in the form of molten ash for **regeneration**. Spent liquors replaces some, and in modern chemical pulp mills all, of the fossil fuels.

Wood waste is likewise burned in special boilers and **thereby replaces fossil fuels**. (For relevance of emissions, see 2.2). Typical **specific energy consumptions** are listed in table 1.2.

2.1.4 Chemicals, auxiliary materials

Although some of the **chemicals to be added**, particularly bleaching agents, such as chlorine, sodium chlorate, caustic soda and peroxides, are bought in by pulp and paper mills, their **production** requires **considerable quantities of energy**. A **reduction in bleach consumption** requires a generally **greater acceptance of less bright paper** on the part of the consumer, but would be a **major environmental protection measure**.

The production of other **auxiliary materials**, such as dyes, starch, clay and resin, is likewise heavy on energy, but is less significant because of the relatively **small quantities used**.

2.2 Emissions from pulp and paper mills

2.2.1 Aqueous emissions

Table 2.2.1A gives a detailed survey of sources, substances emitted, impacts, and reduction measures and the degree of reduction of aqueous emissions, while table 2.2.1B provides information on typical emission limits in terms of quantity.

Considered first are:

- emissions
- their impacts and
- reducing and protection measures

before the downstream treatment plant (wastewater treatment plant). This is **followed by** the effect of these reducing and protection measures.

A: Quantity

The **quantity of wastewater** is approximately the same as the **quantity of fresh water used**. Thus **a reduction in fresh water consumption** by creating internal circuits results in a **reduction in wastewater quantities**, which is also a **major cost factor** when designing wastewater treatment plants.

B: Quality

Quality factors in aqueous emissions are

- content of undissolved substances (settleable/filterable)
- content of dissolved substances, comprising

    reaction products from pulping and chemical recovery
    reaction products from pulp bleaching
    concentrated condensates from chemical recovery
    chemical residues and soluble content of waste paper cleaning
    dissolved substances from paper manufacture and coating
    dissolved substances from secondary installation wastewater.

In terms of **impact** they are all capable of:

changing pH, consuming O_2, causing discoloration or turbidity, they may be toxic, either individually or in combination.

Primary reduction measures are **internal recirculation** before the remaining wastewater and pollutants are transferred to the

C: Wastewater treatment plant

(secondary treatment, downstream plant) where they are purified to such a degree that they can be **discharged into public sewage systems**.

2.2.2 Emissions into the air

There is an wide variety of **major sources** in **pulp mills** and they are affected in some cases by highly complex technical factors. They range from dust produced in raw material crushing, through **vapours and gases escaping from reaction vessels and liquor tanks** to **flue gases from recovery, bark, sludge and oil/coal boilers, the waste gases from lime burning and degassing systems of bleach tanks and bleaching towers**.

In **paper mills**, the situation is less complex, with fewer factors involved, the **main source** being **waste air from dryers**.

Table 2.2.2A gives a detailed **overview** of source, substances emitted, impacts, reduction and protection measures which can be taken inside the mill and the degree of reduction in the most important departments, while **table 2.2.2B** provides **quantity data** relating to typical emissions in the sector, values currently achievable and limit values.

External plants are **avoided wherever possible** in the case of waste air cleaning plants; they are **incorporated** in the various process stages so that the media extracted can be **recirculated**.

The main **emission components** are carbon dioxide and monoxide, dust (wood and mineral), steam, sulphur dioxide, reduced sulphur compounds (mercaptans and the like), nitric oxides and hydrocarbon compounds.

Their most significant **impacts** are:

- they range from being hazardous to health to toxic, they present a fire risk, they give rise to odours and smog, they may be a contributory factor to acid rain and they reinforce the greenhouse effect.

Reduction or protection measures range from internal collection, recirculation, combustion or other chemical conversion processes to downstream (external) gas scrubbers, filters and absorbers.

2.2.3 Solid waste

Table 2.2.3 describes the **sources, materials, impacts** and **possible countermeasures** specific to solid waste.

The **main sources** are as **varied** as for gaseous emissions. They comprise for the most part **wood waste** such as sawdust, bark, fiber bundles, and also **mineral waste** such as lime sludge, sand and **spent auxiliary materials** such as screens, felts, plastic film, wire etc. The main **impact** is the dumping space requirement.

Reduction and protection measures involve essentially a reduction in volume by incineration and the return of recyclable materials to the manufacturer (metal parts, for example).

2.2.4 Noise

The principle **sources of noise** are:

raw material preparation, such as wood debarking and chopping, transport equipment, refiners, vacuum pumps, finishing machines, steam blow-off in the boiler house, drive units.

The **impacts** may range from nuisance and disturbance to nearby residential areas at night to physical health problems and hearing impairment.

Possible **reduction measures** are:

wood debarking and chopping and heavy goods transport in daytime only, since intermittent operation is possible. Also enclosure of machines, and if applicable sound-proofing materials, steam blow-off with silencers only, new plant sited a suitable distance from residential areas. (With few exceptions, machines are already being designed with noise reduction in mind). internal measures: prescription of hearing protection to be in the relevant departments.

3. Notes on the analysis and evaluation of environmental impacts

3.1 Aqueous emissions

The **monitoring** of these emissions demands continuous or semi-continuous **sampling** and appropriate equipment, both for the individual wastewater flows and for the combination of them.

Routine analyses can be confined to temperature, pH, settleable or filterable solids, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD, measured as potassium chromate consumption), fish toxicity, adsorbable organic halogen compounds (AOX) in relevant cases (i.e. where chlorine or bleaching agents containing chlorine are used).

Special analyses include, *inter alia*, the determination of turbidity, colour, odour, conductivity, colloids, oils and fats.

Analysis methods for routine and special tests are listed in **table 3.1.1**.

Minimum requirements for the discharge of wastewater into public sewage systems have been established and have come into effect in a number of countries in order to **assess the environmental impact of aqueous emissions**.

For the **German pulp and paper industry**, the *Wasserhaushaltsgesetz* [*WHG* - Federal Water Act], the *Abwasserabgabengesetz* [*AbwAG* - Wastewater Charges Act] and the *Bundesimmissionsschutzgesetz* [*BImSchG* - Federal Immission Control Act] are of particular relevance. These laws and their enforcement ordinances lay down minimum requirements which must be observed following application of emission-reducing purification or cleaning processes (see in this regard tables 3.1.2A and 3.1.2B).

In **Switzerland**, assessment criteria are established in the ordinance on water discharge "Verordnung ber Abwassereinleitung", in Austria the standards Norm cover this area, and in the **USA**, the "Effluent Limitations Guidelines and New Source Performance Standard for the Bleached Kraft, Groundwood, Sulfite, Soda, Deink and Non-integrated Paper Mills Segment of the Pulp, Paper and Paperboard Mills" in the EPA (Environmental Protection Agency) programme apply.

In **some other countries**, although similar values exist, they are all too frequently in the form of guidelines, and **compliance** with them is **seldom monitored**.

Likewise, **pollutant concentration data** is **often** given **as an assessment criterion**, though it would be more correct to restrict the absolute quantity of the emission. The concentration assessment may well lead to a dilution of emissions to the limit values if adequate fresh water is available, but "dilution is no solution to pollution".

To obtain a **reliable assessment** of the expected emission situation for an extension or new-build project, consideration must be given not only to **emission quantity and quality** but also to the **drainage situation**. The essential **determining factors** here are:

- flow rates with seasonal minima and maxima
- initial loading of watercourses/rivers
- use of water downstream from the discharge point (drinking water, irrigation, fishing, industry).

3.2 Emissions into the air

As the **major part of emissions** into the air and the main emission components (dust, CO_2, CO, NOx) stem from the **combustion plants** for steam generation, the **relevant environmental brief Thermal Power Stations** should be consulted.

Typical sectoral emissions (particularly pulp mills) are:

sulphur dioxide (SO_2), reduced organic sulphur compounds (TRS), chlorine/chlorine dioxide gas (Cl_2, ClO_2), certain hydrocarbons (HC).

The **routine monitoring** of these emissions is in some cases carried out by **continuous display and recording equipment**, which must be **inspected** and **calibrated** by supervisory bodies at prescribed intervals.

Non-continuous inspections (**special inspections**) are carried out on intermittently collected samples by laboratory staff. The **measuring methods** for this are prescribed in Germany by the *TA-Luft* [Technical Instructions on Air Quality Control]. As with wastewater (see above), other countries have their own specific measuring methods which are defined in the relevant clean air regulations.

The substance-specific **emission limits** currently applicable in Germany, in accordance with the TA-Luft, are listed in **table 2.2.2B**. It should be noted in this regard that the TA-Luft does not contain a limit value for **TRS compounds** which are responsible for the odour nuisance generated by sulphate factories. For this reason, the **limit values** currently **contained in the USE-EPA** - which are largely in line with the state-of-the-art - are recommended as guidelines.

The limit values given in table 2.2.2B can be used as guidelines for extension and new-build projects in countries where provisions in this area are inadequate or do not yet exist yet.

3.3 <u>Solid waste</u>

There are only a limited number of **analysis methods** for the **environmental impacts** of solid waste; for example, there are none for bark, sawdust-type wood waste, bale wire, plastic bags and felt. Other solid waste (**constituents of waste sludge, lime sludge, waste gas dust** etc.) is **routinely examined**.

As solid waste cannot be described as altogether typical of the sector, the analysis methods described in the **relevant environmental briefs** (Solid Waste Disposal, Timber) should be consulted.

Limit values to assess the environmental impacts of the aforesaid substances in the form of ordinances are **rarely** prescribed. In Germany they exist in respect of the suitability of **substances for disposal** (see in this regard the environmental briefs Solid Waste Disposal and the Disposal of Hazardous Waste). The Compendium of Environmental Standards also contains information about **substances which** can be **critical in waste sludge** (heavy metals from printing inks, toxic compounds etc.).

3.4 Noise

Noise is **measured and assessed as noise immission**. The unit of measure used in Germany is the dB(A) to DIN standard 45 633.

Immission limits vary according to the type of area, ranging from 70 dB(A) for purely industrial zones to 35 dB(A) for health resort and residential areas as a night limit.

No special measures are required to comply with a noise immission level of around 50 dB(A) in the immediate surroundings of modern pulp and paper mills, provided that the mills are housed **inside buildings** and are fitted with state-of-the-art sound-proofing.

In Germany, for example, this means that a pulp and paper mill can only be built in industrial or principally industrial areas.

If the relatively large amount of land required to build a paper mill is available, the noise restrictions do not in many countries represent a major barrier to such projects. In fact, the noise immission values may be conformed to even outdoor design of mills, as is frequently the case in tropical countries, as long as it is at an **adequate distance** from neighbouring areas used for residential or other purposes requiring protection.

4. Interaction with other sectors

4.1 Areas typical of the sector

4.1.1 Raw materials

Pulp and paper mills are extremely **capital intensive** and have a **very long service life** (some are over 100 years old). For this reason, the **long-term reliability of raw material supplies is of fundamental importance**.

Wood

Planned and organised cooperation with the **forestry** sector is essential. This collaboration can be structured in a number of ways: it ranges from the simple **purchase** of trunk timber, thinning timber or wood chips and sawmill waste through to the **management** of a mill's own forests. In view of the large time span between the planting and the felling of trees, **long-term planning** is required for new-build projects. Proper **afforestation** work is essential, along with the appropriate capital investment and the necessary organisation.

One important aspect of interaction with other sectors is that of **competition** in the standing timber and sawmill waste market (sawmills, plywood manufacture, the wood processing and wood product sector).

Interaction with the **agricultural technology** sector exists in the context of so-called "agro-forestry", in which trees are used to provide shade and as windbreaks. This could be interesting if the correct types of tree for paper production were chosen, and it could also be an additional source of income for farmers.

Other **competition** with pulp wood derives from use of wood as fuel (see the environmental brief Renewable Sources of Energies) or wood for charcoal or building.

Annual plants

With few exceptions, the **annual plants** which can be used for pulp and paper production constitute **waste or by-products** from agriculturally based industries (e.g. sugar production).

In global terms this group is **not significant** as far as paper manufacture is concerned, but may be **important locally** if no wood is available. The raw material potential for pulp and paper production therefore depends on the market for the products of these other industries. Relatively short-term changes in farming programmes can greatly reduce raw material supplies or lead to arable land being withdrawn from production for reasons of pricing policy.

Examples of annual plants

Straw:

Large quantities produced worldwide, but with **low potential for use** due to the costs incurred in its collection, transport and storage; significant emission problems in its processing to pulp. Change of crop programme, e.g. due to introduction of short-stemmed cereal varieties, could jeopardise projects. **Competitive situations** could arise with **a demand for straw as bedding for cattle** or as **fuel for heating and cooking**.

Bagasse:

The sugar cane residues following sugar extraction are **traditionally used in the sugar factory itself as a fuel** (energy self-sufficiency). It is therefore in **competition with fossil fuels** if it is to be used for paper manufacture, hence the interaction with the agro-industry.

Of minor importance in terms of quantity, but interesting in terms of fibre properties are raw materials such as:

Jute:

In the form of jute sticks, the waste from the ailing **jute (textile) industry**. Competition with fuel. Jute cuttings: competition with the textile industry.

Flax:

Flax straw as **waste from the linseed oil industry**. Transport and cleaning very costly. Competition with textile manufacture.

Sisal:

Since sisal is little used now for ship hawsers, efforts are being made to cultivate its use as **a raw material for special papers**. Very high transport and preliminary cleaning costs. Competition with sack and bag production.

Abaca:

Plays a (minor) role in **special paper** production (Philippines) alongside (minimal) use for textile purposes.

Linters:

Waste product from cottonseed oil factories. Is a raw material for special, chemically pure cellulose for the chemical and pharmaceutical industries, also for special papers and filter material. Advantage: produced centrally - at the oil mill. Competition on the product side from wood dissolving pulp.

Bamboo:

Important building material in all countries where it grows (in practice only a natural crop, cultivation difficult), therefore **only limited quantities available** for pulp and paper. Competition exists for use as a vegetable (bamboo shoots).

Esparto or alfa grass:

Like bamboo, it is not cultivated and is collected only for **insignificant quantities of paper production** (special papers) (North Africa and Spain). Competition exists with use as a braiding material.

Waste paper

The **potential for waste paper supply** is directly **dependent** on **paper consumption** in the region or catchment area and on **market price** (determined by the economic climate). In countries with large stocks, lower qualities are most vulnerable to the economic climate.

Waste paper can be an **important raw material** in countries where a paper industry is to be established for a relatively low initial investment.

There are **links** here with the **paper-processing industry**.

In many countries, "competition" exists in the form of the **recycling of paper** which in the end is too dirty for reprocessing (e.g. newsprint which is used first as wrapping matter and finally as toilet paper).

4.1.2 Auxiliary materials and additives

Water:

Since the pulp and paper industry requires large quantities of **water**, there is competition with other sectors, e.g.:

- water for domestic and industrial use,
- agriculture (irrigation),
- other industries which consume water.

This can have a **direct** effect (surface water) or an **indirect and delayed** effect (well water). The competitive situation vis-a-vis agricultural and other businesses can be **mitigated by appropriate wastewater treatment** so that the water can be reused to a greater or lesser extent. However, all aspects of the possible **salination of the soil** must be taken into account here.

The **availability of water** is one of the most important factors in **selecting a suitable site** for a new mill.

The environmental impacts of other **auxiliary materials and additives** are not typical of the sector (chemicals, energy).

4.2 Areas not typical of the sector

Areas which are not typical of the sector but which are **essential** for the operation of a pulp and paper mill and concern mainly the **infrastructure** are simply listed here as an addition to the information given in the various texts (although this list is not exhaustive):

- water supply
- chemical industry, for alkaline chemicals (caustic soda, soda, aluminium sulphate, sulphuric acid, chlorine, sodium and hydrogen peroxide, sulphurous acids etc.) (in this connection refer to the Compendium of Environmental Standards)
- mineral oil industry, for fuel oils, lubricating oils, natural gas, LPG
- mining, for coal and possibly clay, limestone
- power stations, electricity transmission

- transport, roads, railway connections, waterways

and:

- workshops for repair work and maintenance of mechanical and electrical machines and instruments
- general and technical colleges for the basic education of personnel
- hospitals, clinics, for medical care
- social areas.

There is therefore an interaction with many wider **areas** such as regional development, planning of locations, general energy planning, schools, health services, water supply and distribution planning, transport and traffic planning etc.

5. Summary assessment of environmental relevance

Given the state-of-the-art in the pulp and paper industry, and the technology developed or adapted for it in the field of **recirculation, reduction or prevention of emissions which pollute the environment** with **proper operation monitoring**, the following points can be made:

- With regard to wood as a renewable raw material, this industry is environmentally sustaining as long as the **quantity of wood used is less, or possibly equal to the quantity growing to replace it**. A further environmental protection feature arises with the processing of wood residues and waste (sawmill and brushwood) in pulp mills.
- In the case of **annual plants** the environmental impact is considerably less positive - the alternative use (fuel in the case of bagasse) involves **replacement in the form of fossil fuels** and therefore has

negative impacts for the global CO_2 balance, among other things.

- The still increasing **use of waste paper** as a raw material has generally **positive environmental impacts**: the processing of waste paper consumes less primary energy than fresh pulp and, overall, reduces the wood consumption per tonne of paper.
- **Chemically produced pulp** merits particular mention: in terms of both raw materials and energy, a modern production plant uses renewable feedstock (wood) only and therefore has no impact on the global CO_2 balance.
- **Aqueous emissions from pulp production** are minimal in the case of unbleached pulp (as long as the mill is equipped with a recovery system), and the increasingly common **replacement of chlorine and chlorine compounds as bleaching agents** with chlorine-free media (oxygen and peroxide) already enables a large number of bleaching installations to comply with the relevant limit values.
- **Aqueous emissions from paper manufacture** can also be kept below the relevant limit values without difficulty by the **use of water recirculation measures** and highly **efficient water treatment plants**.
- **Gaseous emissions from power station and recovery installations** can be kept below limit values with the cleaning/scrubbing techniques developed. **Odour emissions** (mercaptans) are still a **problem**, particularly in the case of sulphate pulp factories. However, systematic collection and control measures in modern European plants are also achieving acceptable reductions below the (EPA) limit values in densely populated areas.
- Only a small quantity of **solid waste** is produced, and a large proportion of it can be **used for energy** (bark, wood waste). In the area of waste sludge disposal (incineration, dumping), attention must be paid to the **problems of heavy metals from printing inks** where mills use waste paper.
- The **outdoor design** of mills, normally applied in warmer climates, makes **noise prevention measures more costly** than in enclosed plants, thus noise nuisance can only be prevented by siting such mills **further** from residential areas.

In temperate and/or cold climates, the question of noise can easily be resolved by building design, insulation and process management (avoiding operating noise-emitting departments at night).

The **early involvement of the population groups affected,** particularly women, in the planning and decision-making process, means that **their interests** can be **taken into account** and helps **reduce environmental problems** (e.g. competition for the use of water, wood and land).

The **implementation and monitoring of emission limit values** and a generally **environmentally oriented operation** are only possible if the necessary **control bodies** are **institutionalised** and **operate effectively**. One option is to **appoint industrial environmental protection officers**, who should also be responsible for the **training and further education** of personnel and **increasing the awareness of personnel** for environmental matters.

6. References

W Brecht and H. L. Dalpke: "Wasser, Abwasser, Abwasserreinigung in der Papierindustrie".

Deutsches Wasserhaushaltsgesetz (WHG), Abwasserabgabengesetz (AbwAG) and the Bundesimmissionsschutzgesetz (BImSchG).

EPA (Environmental Protection Agency) "Effluent Limitations Guidelines and New Source Performance Standards for the Bleached Kraft, Groundwood, Sulfite, Soda, De-ink and Non-integrated Paper Mills Segment of the Pulp, Paper and Paperboard Mills".

NCASI, USA (National Council of the Paper Industry for Air and Stream Improvement), Bulletins (div.).

Norm M 94 64.

Allan M. Springer: "Industrial Environmental Control, Pulp and Paper Industry".

SSVL Sweden (Sriftelsen Skogsindustriernas Vatten och Luftvardsforskning), The SSVL Environmental Care Project.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Appendix A: Tables

Contents - Previous - Next

Table 1. 2. Basic Data Relating to Pulp

Abbrev.	Type	Yield as a % of raw material		Spec. energy consumption (kWh/t pulp)		Rel. chemical use in relation to raw material		Rel. pollutant output after process untreated,		Rel. environmental impact after treatment (a)	
		Wood	Annual plants	Wood	Annual plants	Wood	Annual plants	Wood	Annual plants	Wood	Annual plants
GW	"mechanical" stock (wood pulp)	99-100	--	1600-2000	--	very low	--	low	--	low	--
TMP	Thermo-mech. pulp	97-98	--	1800-2400	--	very low	--	low	--	low	--

CTMP	Chem. thermo-mech. pulp	91-97	--			low	--	medium	--	low	--
CMP	Chem. mech. pulp	82-96	(70-80)	min. 930	min. 600	medium	(medium)	medium	medium	low	low
SCP	Semi-chemical pulp	62-82	50-60	800-900	500-600	high	medium	high	high	low	low/very high (c)
CP	Chemical pulp	40-60	30-40			very high	high	very high	very high	low/medium (b)	low/very high (c)
AP	Waste paper stock	80-95		200-400		low		low/medium		low	

(a): state-of-the-art emission treatment
(b): noxiousness dependent on the type of bleaching chemicals: with or without chlorine
(c): dependent on the technical or economic feasibility of recovery or destruction of spent pulping chemicals

Table 2.2.1A Aqueous Emissions Pulp and Paper Mills Page 1				
Sources/causes typical in sector	Substances emitted	Impacts	Reduction measures (state-of-the-art) in mill	Degree of reduction (%)

Open water circuits	Large quantity of wastewater	Large treatment plant, high energy and chemical consumption	Closing of internal circuits	To approx. 80%
Undissolved substances from various sources/ careless process control	Organic fibre components and inorganic components (dirt), filler remains	Turbidity, color, oxygen consumption, smell	Division of process water flows, closing of circuits in mill, improved filtration	Varies depending on production type
Dissolved substances from pulp production and recovery	Ligno-sulphonates, other lignin decomposition products, crude tall oil etc., organic sulphur compounds, Na salts	Marked brown coloration, oxygen consumption (in part difficultly degradable), odour nuisance	Optimisation of process stages, leak prevention, recycling of leaked liquid	Up to 90%
Pulp bleaching	Decomposition products of lignin and hemicellulose, chlorinated organic compounds, Na and Cl salts	Oxygen consumption (in part difficultly degradable), discoloration, toxicity	Recycling of filtrates in plant, leak prevention, conversion to chlorine-free/ low-chlorine bleaching	Chlorinated compounds up to 100%, others only slightly
Condensates	Organic compounds	High oxygen	Liquor stripping	Up to over 90%

	(methanol, ethanol, uncondensed gases)	consumption , color, odour nuisance	in/before condensation, combustion or separate processing of stripper gases	

Table 2.2.1A Aqueous Emissions Pulp and Paper Mills Page 2

Sources/causes typical in sector	Substances emitted	Impacts	Reduction measures (state-of-the-art) in mill	Degree of reduction (%)
Chemicals from waste paper pro-cessing	Printing ink components (in part containing heavy metals), dyes, processing chemicals, complex salts	Turbidity, oxygen consumption, toxicity (with heavy metals)	Closed circuit management (restricted), toxicity can be reduced indirectly by using printing inks without heavy metal components	Oxygen consumption low, toxicity high
Paper manufacture	Remains of chemical additives (dyes, brighteners, anti-foaming agents, retention and cleaning agents, fillers)	Turbidity, oxygen consumption (toxicity, if additive toxic)	As for waste paper	As for waste paper

Coating plant	Coating materials (latex, clay, emulsifiers, starch etc.)	Turbidity, oxygen consumption	Careful process management to prevent losses	--
Wastewater from secondary installations	Chemicals from water softening/ demineralisation, clarification salts etc.	Salt content	--	--

Table 2.2.1A Aqueous Emissions Pulp and Paper Mills Page 3

Sources/causes typical in sector	Substances emitted	Impacts	Reduction measures (state-of-the-art) in mill	Degree of reduction (%)
Wastewater treatment plant	A) In the wastewater: oxygen-consuming substances (lignin and cellulose decomposition), dyes B) In treated sludge: organic and inorganic solids	Turbidity, discoloration, oxygen consumption --	Mechanical (sedimentation, filtration, flotation), biological (aerobic, anaerobic) and possibly chemical (precipitation, adsorption with active carbon etc.) wastewater	Colour: 95%, oxygen: up to around 60%, (pulp) and up to 95% (paper), colouring: up to 100% Over 90%

	(incl. toxic components), products of bio-degradation		treatment Sludge incineration (possibly with flue gas scrubbing)	

Table 2.2.1 B Examples of Quantitative Emission Values Aqueous emissions, pulp production, untreated

Table 2.2.1 B Examples of Quantitative Emission Values						
Aqueous emissions, pulp production, untreated						
	Wastewater quantity m/t	**BOD kg/t**	**COD kg/t**	**ss kg/t**	**AOx kg/t**	**TOX (TEF)**
Wood pulp TMP CTMP SC C sulphate C sulphite	1) 2) 20 8 50 50 225 450	1) 2) 10-30 15-28 315) 10-20 40-605) 250-500∗ 60-200∗ ∗	1) 2) 3xBOD 3xBOD	1) 2)	3) 4) 1-2 5 0-0.2 5	
Aqueous emissions, paper production, untreated						

<u>Graphic papers</u>						
Newsprint	25 80	1-2		10 40		
MF writing and	70 180			30 80		
printing			0 - 3		--	6)
papers	0 50	0 3		0 10-30		
<u>Industrial papers</u>						
Common wrapping papers						

∗ : no chemical recovery

∗ ∗ : with chemical recovery

1) with water circuits largely closed in the mill

2) with water circuits largely open

3) with chlorinated bleaches largely avoided

4) with chlorinated bleach

5) value range SSVL (Sweden)

6) printing inks containing heavy metals can yield toxic sludges

TEF Toxicity Emission Factor

Table 2.2.2 A Emissions into the Air Pulp and Paper Mills

Table 2.2.2 A Emissions into the Air Pulp and Paper Mills Page 1				
Sources/causes typical in the sector	**Substances emitted**	**Impacts**	**Reduction measures (state-of-the-art) in the mill**	**Degree of reduction (%)**
Raw material crushing and cleaning (chopping of wood, straw etc.)	Organic dust	Fire risk constituting health hazard	Extracting of air and cleaning in cyclones (and/or filtering, recycling, burning or dumping of dust)	up to 100%
Waste gases from digesters, steaming out of equipment and vessels	Steam, turpentine, other HC compounds, SO_2	Fire risk, odour nuisance, health hazard, acid rain	Condense steam and turpentine, recycle turpentine, burn residue, recycle SO_2 in the process, scrub residual gases	99 +
	TRS	Odour nuisance	Collect and burn TRS (cannot be condensed)	99 +
Fumes of spent liquor condensation plant	Steam, terpenses, methanol, TRS	Odour nuisance	Collect and burn gases	95 +

	Steam	--	--	--
	SO_2	Acid rain	Absorption in alkaline gas scrubbers, recycling in process	99 +
	NO_2	Ozone formation	In development: noncatalytic conversion	0
	TRS	Odour nuisance process	State-of-the-art process	99 +
Recovery boiler (waste gases)	CO	Health hazard	Minimise by process	0
	CO_2	Greenhouse effect	Unavoidable, does not pollute global balance	0
	Dust	Health hazard	Electro-filters, recycling in process	99 +
Table 2.2.2 A Emissions into the Air Pulp and Paper Mills Page 2				
Sources/causes typical in the sector	**Substances emitted**	**Impacts**	**Reduction measures (state-of-the-art) in mill**	**Degree of reduction (%)**
	Steam	--	--	--
	SO_2	Acid rain	Use of S-free fuel oil or natural gas; in development: wood and	95 +

			bark gas	
	CO	Health hazard	Minimise by process management	0
Lime kiln (waste gases)	NO_x	Ozone formation	Reduction not yet state-of-the-art (cf. cement sector)	0
	TRS	Odour nuisance	Minimisation possible by good process management	99 +
	Dust	Health hazard	Electric filters and recycling in process	99 +
	Steam	--	--	--
Steam boiler fired by bark or waste wood	CO_2 and CO	Greenhouse effect, health hazard	Unavoidable, but does not affect the global balance, minimisation by process management	
(waste gases)	Hydrocarbons	Greenhouse effect, health hazard	Minimisation by process management	as above
	NO_x	Ozone formation	In development: conversion from non-catalytic to catalytic	

	Steam	--	--	
Furnaces to destroy sludges and residues	CO_2 CO	Greenhouse effect, health hazard	As above , minimisation by process management	as above
	NO_x	Ozone formation	Currently not state-of-the-art	
	Dust	Health hazard	Scrubbers, cyclones, dump	

Table 2.2.2A Emissions into the Air Pulp and Paper Mills Page 3

Sources/causes typical in sector	**Substances emitted**	**Impacts**	**Reduction measures (state-of-the-art) in mill**	**Degree of reduction (%)**
Fumes of bleaching towers, bleach preparation, chlorine transport	Chlorine Chlorine dioxide SO_2	Health hazard " "	Extract fumes and wash in scrubbers, return to process	Up to 100
Waste air from transport equipment for raw materials and products	Motor exhaust NOx, CO, HC, CO_2	Health hazard, atmospheric effects	Catalysts, diesel operation with soot filters, use of electric vehicles where possible	Up to 90
Paper dryer,	Steam	--	--	--

paper machine (ditto coating and laminating machines)				
	Organic solvents	Health hazard	Gas scrubbing, carbon filters with recovery, also use of water-soluble auxiliaries	Up to 95
Processing of additives, waste air from vacuum pumps	Steam	--	--	--
Waste air from transport equipment for raw materials and products	Motor exhaust, NOx, CO, HC, CO_2	Health hazard	Catalysts, diesel with soot filters, use of electric vehicles where possible	Up to 90

Table 2.2.2B Emissions into the Air Typical for the Sector, State-of-the-Art, Limit Values

Table 2.2.2B Emissions into the Air Typical for the Sector, State-of-the-Art, Limit Values			
Emission	Source	State-of-the-art	Typical limit

		mg/Nm3	values mg/Nm3
Dust	- Power boiler - Absorption plant, Mg, Ca bisulphite and magnefite process - Lime-burning kiln - Smelt-dissolving tank	less than 50 less than 50 less than 50 less than 50	50 (Norm) 50 (Norm) 50 (Norm)
SO_2	- Power boiler - Absorption plant, Mg, Ca bisulphite process - Ditto magnefite process - Lime-burning kiln with TRS burning	less than 50 less than 250 less than 250 less than 400	400 (norm) 700 (Norm) 300 (Norm) 400 (Norm)
CO	- Power boiler - Lime kiln	less than 100 less than 250	cf. TA-Luft generally: oil-fired: 170 solid fuel: 250
Organic C	- Lime kiln	less than 50	150 mg/m3 (TA-Luft)
NOx	- Power boiler - Lime burning kiln	less than 200 less than 900	400 mg/m3 HMW (LRV-K, 1989) (1,500 TA-Luft, rotary kiln for

			lime)
TRS	- Power boiler - Lime-burning kiln - Smelt-dissolving tank	less than 5 ppm V less than 8 ppm V 8.4 g/t BLS	5 ppm V (EPA) 8 ppm V (EPA) 8.4 g/t BLS (EPA)
Inorganic Chlorine/ Chlorides	- Bleaching plant - Chemical processing	Cl_2 and CL: less than 10 mg/m3	Cl_2: 5 mg/m3 (TA-Luft Cl: 30 mg/m3 as HCl (TA-Luft)
HMW: Mean hourly value LRV: Luftreinhalteverordnung (ordinance on clean air)			

Table 2.2.3 Solid Waste Pulp and Paper Mills

Table 2.2.3 Solid Waste Pulp and Paper Mills Page 1				
Sources/causes typical in sector	Substances emitted	Impacts	Reduction measures (state-of-the-art) in mill	Degree of reduction (%)
Raw material transport and	Bark Wood shavings	Space required	Burning for energy	> 95

preparation: Wood			generation	
Straw	Binding wire	"	Collection, compacting, scrap trade	--
Pulp cleaning	Knots, bundles of fibre, sand	" "	Incineration for energy generation, dumping	> 95 0
Quality Control	Rejected product	"	Return to process	> 85
Chemical recovery, removal of foreign ions	Lime sludge* or lime Sulphate soap**	Ground water pollution Process problems	Recycling in lime-processing industries, dumping Recycling as raw material for chemical works	0 - 80 Up to 100
Waste paper treatment	Iron wire, plastic film, string	Space required	Dumping	--
Waste paper de-inking	Printing ink sludge	Ground water contamination	Incineration or special dump	Up to 85

	(may contain heavy metals)			
* in sulphate and soda pulp mills ** ditto for softwood				

Table 2.2.3 Solid Waste Pulp and Paper Mills Page 2

Sources/causes typical in sector	**Substances emitted**	**Impacts**	**Reduction measures (state-of-the-art) in mill**	**Degree of reduction (%)**
Water and wastewater treatment	Fibre sludge, inorganic sludge, biological sludge	Space required	Recycle or burn fibre sludge	Up to 85
			Dump inorganic and biological sludge, under certain conditions also use for soil improvement	--
Wear of consumables	Metal, plastic screens, synthetic	Space required	Return to manufacturer for recycling,	--

	textiles (felts), lubricants, cleaning agents		dump, burn	
Mill maintenance	Defective machine parts Packaging material		Return to manufacturer for recycling, (scrap), burn or dump	--

Continue

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Table 3.1.1 Methods of Wastewater Analysis and Possibilities for Reducing Environmental Impact

Contents - Previous - Next

Table 3.1.1 Methods of Wastewater Analysis and Possibilities for Reducing Environmental Impact Page 1				
	Pollutant/	Unit	Analysis method	Methods for

	properties			elimination or reduction
1	Undissolved substances	mg/l	DEV H_2, SM 148, 224	Mechanical treatment, flocculation, biol. treatment
2	Substances which can be precipitated	mg/l	DEV H_2, SM 224, z x/1/76	Mechanical clarification, flocculation, biol. treatment
3	Suspended matter	mg/l	Difference from 1 and 2	Flocculation (filtration), biol. treatment
4	Turbidity	cm visibility	DIN standard 38 404-C_2, SM 163, 232	Flocculation (filtration), biol. treatment
5	Colours		DIN standard 38 404-C_1, SM 118, 206	Flocculation, coagulation, flotation
6	Temperature	C	DIN standard 38 404-C_4, SM 162	Cooling (towers, lagoons, trickling filters)
7	Odour		DEV $B_{1/2}$,	

			SM 136, 217	
8	pH		DEV C_5/S_5, SM 144, 221	Neutralisation
9	Conductivity	S/cm	DEV C_8, SM 154, 226	

Table 3.1.1 Methods of Wastewater Analysis, and Possibilities for Reducing Environmental Impact
Page 2

	Pollutant/ properties	Unit	Analysis method	Methods for elimination or reduction
10	Total, evaporation, and incineration residue	mg/l	DEV H1/S3, SM 148, 224	
11	BOD	mgO_2/ l	DEV H5, SM 141, 219 DIN 38409-H91	Biodegradation, aerobic, anaerobic
12	COD	mgO_2/ l	SM 142, 220 Z x/2/76 DIN 38409-H41 and - A_{30} ARAVwV1) no.303	Biodegradation, aerobic, anaerobic
13	Total organic carbon, TOC	mgC/l	SM 138	
14	Oxygen	mgO_2/ l	DEV G2/J8, SM 140, 218	

15	Total nitrogen, organic	mg/l	DEV H11, H12	Biodegradation, aerobic, anaerobic
16	Colloids	mg/l	DEV H3	
17	Oils, fats	mg/l	DEV H17, H18 SM 137, 209	Separators
18	Lignin, tannin	mg/l	SM 160	
19	Hydrocarbons	g/l	DEV H15	
20	Organic poisons	g/l	SM 139	Biodegradation

Table 3.1.1 Methods of Waste Water Analysis, and Possibilities for Reducing Environmental Impact
Page 3

	Pollutant/ properties	Unit	Analysis method	Methods for elimination or reduction
21	Phosphorus	mg/l	ARAVwV no.108	
22	Nitrogen	mg/l	ARAVwV no.106/107, 202	
23	AOX	g/l	DIN standard 38409-H14, ARAVwV no.302	
24	Chloride etc.	mg/l	DEV D5-7, D15, J7, SM 156 - 158, 228	Ion exchange, ultra-filtration, rev. osmosis

25	Nitrate, nitrite	mg/l	DEV D9-10, E5 SM 131-135, 212-216	Biological decomposition
26	Heavy metals	mg/l	SM 211, ARAVwV no.207 (Ca) no.209 (chromium)/214 (Ni)/206 (Pb)/213 (Cu)/215 (Hg)	Flocculation
27	Na+ etc.	mg/l	DEV H13-15, SM 126, 147, 153	Ion exchange, ultra-filtration, rev. osmosis
28	Toxicity and biodegradability		DEV L2-3	
29	Population equivalent		DEV L1	
30	Toxicity to fish	TF**, %, TEF*	DEV L15, SM231 DIN standard 3842-L20, ARAVwV 401	
31	Biological/ ecological water inspection (water quality classes)		DEV M1-7, SM 601-606	

<u>DEV</u>: Deutsches Einheitsverfahren [German standardisation procedure]

SM: Standard methods (APHA)

Z: Zellcheming code of practice

1) ARAVwV: Appendix to the Rahmen-Abwasser-Verwaltungsvorschrift of 08.09.1989 [General Administrative Framework Regulation]

*** TEF: toxicity emission factor ** TF: toxity to fish**

Table 3.1.2A
(Minimum) Wastewater Requirements (specific)
As at January 1990 in Germany

Type of pulp or paper	COD kg/t max. 2)	BOD kg/t max.	BOD mg /l	AOX kg/t max.	Toxicity to fish TF max.	Substances which can be precipitated ml/l max.
Pulp (generally)	70	5		1**	2	
Paper: writing and printing	5 - 7	0.7 -6	25		0.5	0.5 0.5

papers, depending on type						
Based on waste paper	6	1.2				0.5
Parchment	12	6			0.5	0.5

2) Tonne, air dry = 0.9 t absolutely dry

****) Not applicable to dissolving pulp until 31.12.1992**

Table 3.1.2b Pollutant Units for the Measurement of Wastewater Discharges in Germany			
No.	Pollutants and pollutant groups assessed	The following units of measurement are equivalent to one pollution unit in each case	Threshold values by concentration and annual quantity
1	Oxidizable substances in chemical	50 kilograms oxygen	20 milligrams per litre and 250 kilograms annual quantity

	oxygen demand (COD)			
2	Phosphorus	3 kilograms	0.1 milligrams per litre and 15 kilograms annual quantity	
3	Nitrogen	25 kilograms	5 milligrams per litre and 125 kilograms annual quantity	
4	Organic halogen compounds as adsorbable organically bound halogens (AOX)	2 kilograms halogen, calculated as organically bound chlorine	100 micrograms per litre and 10 kilograms annual quantity	
5	Metals and their compounds:		and	
5.1 5.2 5.3 5.4 5.5 5.6	Mercury Cadmium Chromium Nickel Lead Copper	20 grams 100 grams 500 grams 500 grams 500 grams 1,000 grams of metal	1 microgram 5 micrograms 50 micrograms 50 micrograms 50 micrograms 100 micrograms per litre	100 grams 500 grams 2.5 kilograms 2.5 kilograms 2.5 kilograms 5 kilograms annual quantity
6	Toxicity to fish	3,000 cubic metres of	TF = 2	

		wastewater divided by TF		

TF is the dilution factor at which the wastewater is no longer toxic in the fish test.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Appendix B: Glossary

Contents - Previous - Next

Absolutely dry also called "oven dry" (= b.d. bone dry)

AP Waste paper

APHA American Public Health Association

APMP Alkaline peroxide mechanical pulp (special form of CTMP).

BLS Black liquor solids.

Brightness Measure of the "whiteness" of the paper, expressed as a percentage of "absolutely" white = 100% light reflection under blue light of a certain wavelength. Very bright papers have a brightness of 85 - 90%, newsprint around 60 - 65%.

Corrugating medium Relatively strong paper for the corrugated central layer of corrugated board.

De-inking Removal of printing inks from printed waste paper.

Dissolving pulp High quality chemical pulp for further chemical processing (films, fibers, etc.)

EPA The Environmental Protection Agency, USA.

"Fresh" pulp "Virgin" pulp obtained from the various raw (wood, etc.) fibre materials (as opposed to waste paper pulp).

Lime burning kiln Installation for chemical recovery in sulphate and soda pulp mills for the regeneration of burnt lime for the reprocessing of dissolving chemicals.

Mg and Ca bisulphite Chemical pulping process.

magnefite process

Refiner Grinding machine for the pulping and fibrillation of fibrous raw materials. Mostly disc refiners with toothed or grooved counter-revolving discs at low adjustable distances.

Rigidity Resistance to bending and folding of paper and board. Important for pressure loads where used for packaging purposes.

Shelf life Generic term for paper and board which concerns resistance to light, moisture and resistance to heat.

Smelt-dissolving tank Dissolving tank for ash from black liquor burning (sulfate process).

Strength For paper and board, a non-scientific generic term for tensile strength (breaking length), bursting strength, folding coefficient, edge tearing resistance.

TRS Total reduced sulphur, generic term for H_2S and organic compounds with bivalent sulphur, e.g. mercaptans. Usually have an unpleasant odour at the tiniest concentrations.

Yield Ratio of quantity of product (absolutely dry) to quantity of raw material (absolutely dry) expressed as a percentage. Because in the trade, pulp is calculated at 90% dry matter content (10% moisture, called "air dry"), the yield can also be given on this basis. Vegetable raw materials contain from around 30% (for straw) to around 50% (for wood) pulp; yields are limited by this.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

59. Textile processing

Contents - Previous - Next

Contents

1. Scope

1.1 Terminology

A "textile mill" is generally defined as an industrial production plant which processes

materials which can be spun, such as fibres, threads, yarns, twines, fabrics, knitted fabrics, fleeces, felts, synthetic skins and such like.

The "clothing" industry further processes the majority of products from the textile industry, but this environmental brief only considers the "textile industry".

1.2 Raw material

The textile industry originally processed exclusively natural, and for the most part indigenous raw materials obtained from both plants and animals (plants: cotton, flax, sisal, ramie, jute; animals: wool, silk, hair). However, the proportion of synthetic fibres (regenerated cellulose fibres such as synthetic silk, viscose staple fibre from wood and cotton waste, and later fully synthetic fibres such as polyamide, polyacrylic and polyester fibres, the raw material for which is petroleum) of the total fibre demand is on the increase throughout the world. In 1990, the chemical fibre industry covered some 45% of the worldwide demand for textile fibres, standing at 42.9 million tonnes.

Chemical fibre manufacture and its attendant environmental problems are not the subject of this environmental brief as it is in fact part of the chemical industry.

1.3 Production stages

1.3.1 Fibre conditioning

All natural fibres are polluted with extraneous matter and substances, and first have to be rendered "spinnable" by conditioning processes, some of which are expensive. By far the majority of natural fibres are produced in tropical or subtropical countries, not the industrialised world. This is where primary conditioning is also carried out, involving, for example:

- **cotton ginning**
- **degumming of sisal, hemp and flax**
- **unreeling and degumming of silk and**
- **washing of wool.**

Natural fibres are now being produced on a large scale, i.e. in "agrarian factories", characterised by single-crop agriculture. The problems which inevitably ensue (uprooting of new farmland, terracing, prevention of reforestation by overgrazing etc., social problems) must be taken into account when siting and planning such facilities.

1.3.2 Spinning and yarn production

Yarns/threads/twines are manufactured in specialised spinning mills according to the raw material and intended future use: cotton or 3-cylinder spinning mills, worsted, woollen and bast fibre spinning mills etc., the first of these being the most commonly used type. Indeed, over the last two decades, it has become firmly entrenched alongside the traditional OE rotor spinning process (OE = open end) as it produces considerably more cheaply, especially in the

case of coarser yarns.

All spinning mills operate more or less on the basis of the same process: the fibrous material is (where necessary) further cleaned, aligned and, while being stretched and rotated about its axis, spun to a thread. Some of the yarn produced in this way is then twisted, i.e. two or more threads are combined by rotation to form a "twisted" yarn.

The finished yarns are today supplied to the subsequent processing stages in the form of so-called cheeses, i.e. bobbins weighing between 0.8 and 3.5 kg.

1.3.3 Weaving and knitting mills

Of these textile production techniques, weaving is by far the most important. It involves the production of a fabric from a set of threads aligned in one direction, called the "warp", by interlacing "weft" threads at right angles to it. Considerable technical improvements have been made to the looms used for this purpose in the last twenty years, resulting in a marked increase in productivity.

One particular feature of the production of woven fabrics is sizing. For certain articles one of the two thread systems, the warp, must be protected by a kind of glue coating, which involves "sizing" the warp threads with a protective coating - e.g. modified starch or a synthetic polymer - by immersion.

Unlike woven goods, knitted products have only one thread system, i.e. the threads which are made into a mesh run diagonally or longitudinally. The items are produced on linear or circular knitting or hosiery machines or warp knitting machines.

1.3.4 Textile finishing

The term textile finishing covers the bleaching, dyeing, printing and stiffening of textile products in the various processing stages (fibre, yarn, fabric, knits, finished items). The purpose of finishing is in every instance the improvement of the serviceability and adaptation of the products to meet the ever-changing demands of fashion and function.

Finishing processes can be categorised into purely mechanical and wet processes. The liquid phase for the latter type is primarily water, and - to a lesser extent - solvents and liquefied ammonia gas. Another important medium is steam. To achieve the desired effects, a range of chemicals, dyes and chemical auxiliaries are used.

Compared with textile production, textile finishing mills are generally smaller, offer a more diverse range of services and are less automated.

1.4 Mill sizes

1.4.1 Spinning mills

Spinning mill capacities are expressed in terms of "spindles" or "rotors", i.e. the number of these units installed. For purposes of comparison, one rotor equals approximately 3 - 4 spindles.

In the Federal Republic of Germany, cotton spinning mills have an average of 13,000 spindles and 1,100 rotors with 150 employees, while the figures for worsted/woollen mills are some 9,500 spindles and 120 employees.

In raw-material-producer countries mill sizes generally far exceed the average values stated above (up to 120,000 spindles/mill).

1.4.2 Weaving and knitting mills

Weaving mill capacities are normally expressed in terms of the number of looms.

In the Federal Republic of Germany the average mill size is 46 looms and 106 employees. Weaving mill projects in raw material producer countries are mainly for far larger units with up to 2,000 looms/mill.

In knitting mills, the number of installed production units gives no direct clue to production capacity because, in addition to piece goods sold by the metre, a wide range of finished goods (outer wear and underwear, hosiery etc.) is manufactured.

Capacities are therefore expressed in a number of ways according to product type: in tonnes (yard ware), 1,000 units (outer wear and underwear), 1,000 pairs (hosiery) or 1,000 m (curtains). In 1991, the average mill size in the Federal Republic of Germany was 91 employees.

1.4.3 Textile finishing

Depending on the type of products finished, finishing capacities are expressed in t/year (fibre, yarn, knitted goods), million m/year (fabric) or 1,000 items/year (ready to wear articles).

In the Federal Republic of Germany, the average production output for the total of 320 mills in the sector was calculated to be 2,500 t finished goods/mill and year in 1990 with an average of 116 employees per workshop.

Large mills in the USA and in Asia can have capacities of up to 50,000 t/year.

1.5 Site issues

In textile industry projects particular attention must be paid in all cases to the large quantities of water required for the finishing operations, which is why appropriate disposal facilities must naturally be provided for the process water.

With increased automation the space required by textile mills has declined. New mills have a more compact structure for shortening transport distances, among other things. The land

requirement for a medium-sized vertical mill, including yard and access route areas and infrastructure systems with expansion options, is some 60,000 m.

2. Environmental impacts and protective measures

2.1 Fibre conditioning

Before they are processed, all natural fibres must be conditioned. This involves the removal of all manner of extraneous matter.

The by-products of conditioning (cottonseed and linseed, wool fat, silk gum) are in some cases commercially viable substances, and dry waste can in theory be returned in the soil as fertiliser, although another method of treating it is to compost it. A large proportion of the "waste" produced when native fibres are cleaned may therefore be regarded as commercial commodities, although all this requires additional treatment.

With regard to emissions, only cotton ginning and raw wool washing are of special significance.

Only about one third of the weight of a cotton boll is in the form of spinnable fibres. When the cotton is ginned (cleaned) - an operation normally carried out in situ - cotton seeds are

obtained as a by-product, from which cotton seed oil and meal are produced. Another by-product is known as linters, which are used amongst other things in the manufacture of synthetic silk and viscose (spun rayon). The actual husks and waste constitute some 15% of the weight of the cotton boll and can be ploughed back into the soil.

Ginning is a dry, mechanical process which generates considerable noise and quantities of dust. While the latter of these two problems can be greatly relieved in modern mills by the use of extractor and filter systems, the wearing of ear protection is absolutely essential to combat the former.

Emissions from raw wool washing are far more problematic. In contrast to cotton ginning, raw wool is washed centrally in large industrial facilities remote from the place where the wool is obtained. The operation yields between 300 and 600 g attendant material per kg of washed wool. In addition to the wool fat which is a saleable commodity per se, being used for technical and cosmetic purposes, biocides and the like from sheep's wool are present in the washing water. Raw wool washing may therefore be regarded as one of the major wastewater pollution problems in the textile industry.

Today, wool fat is generally extracted before the wastewater is discharged.

A further factor to be considered is that complex purification plants are used to condition the still highly polluted wastewater (COD around 15,000) so that it can be discharged into the drains (on the subject of wastewater purification, see also the environmental brief Mechanical

Engineering, Workshops, Shipyards and Wastewater Disposal).

2.2 Spinning and yarn production

Because of the high spindle speeds reached on new machines (ring spindles up to 20,000 rpm, rotor up to 110,000 rpm), spinning mills can generally be assumed to generate a great deal of noise.

Noise levels of 70 to 100 dB(A) are commonly recorded in work rooms.

As the spinning process calls for a specific room climate, i.e. temperature and relative humidity, which must be as constant as possible and not affected by time of day or night, or season, practically all spinning mills today are fitted with powerful air-conditioning systems. To limit the cost of air-conditioning, the production plant must be well insulated against external temperature changes. In the sixties and seventies this led to a windowless architecture for textile mills with extremely good values for insulation against temperature variations and against noise.

Since the eighties, windowless designs have been frowned upon by the building authorities in the light of the physiological and psychological problems caused to employees. To improve workplace design fields of vision of around 2 to 5% of the floor area of the workrooms must be provided, and special glazing is needed for this.

The high mechanical stress on fibres during the spinning process results in the production of considerable quantities of dust, which must be carefully extracted for industrial safety reasons and in order to keep the product clean. Emissions can be prevented and dust extracted by means of special machine enclosures and extraction systems and via the air-conditioning system which keeps the air in the rooms circulating. Air is not reintroduced until it has been passed through automatic filter installations. The filter dust is not dangerous and its disposal is therefore not a problem.

2.3 Weaving and knitting

Although considerable progress has been made in the weaving sector over the last twenty years, the whole area of noise nuisance and, closely associated with it, vibrations coming from looms, cause major problems.

Noise levels of 85 to 107 dB(A) must be expected in weaving rooms, according to the design, type, fitting, erection and number of looms used, fabric structure, building type and size etc. The vibrations transmitted from the running looms to the building can, under certain circumstances, cause a nuisance to the local population and damage to nearby buildings, and to avoid this special vibration absorbers are now provided. Generally speaking, the comments made about noise and dust emissions with regard to spinning mills apply here too.

The sizing of warp threads in weaving mills gives rise to emission problems.

Natural substances such as starch and cellulose products and synthetic products such as polyvinyl alcohol, acrylates, PVC, oils and fats are used as sizing material.

The evaporation fumes produced during the drying stage consist mainly of steam. The small amounts of sizing agents contained are not regarded as environmental pollutants.

On the other hand the sizing liquor may no longer be discharged into wastewater in Germany as it is a "concentrate" according to *Anhang 38* [Appendix 38] to the *Rahmen-Abwasserverwaltungsvorschrift* [General Administrative Framework Regulation on Wastewater].

However, the sizing coating itself has much more serious repercussions in the subsequent textile finishing stage where the size first has to be completely removed. In finishing works which handle primarily woven goods, up to half the wastewater pollution may derive from dissolved sizes during washing.

There is currently a trend in the USA towards the use of sizing agents which can be recycled; this aids the work of the finisher in terms of disposal, and also saves up to 90% of sizing agent due to recycling. In Europe, where the textile industry, in contrast to the USA, is largely horizontally structured, this trend has yet become established. From the point of view of recycling, which is attracting increasing economic interest, this could provide a certain environmental benefit in the woven products sector.

Emissions in the knitting industry are substantially lower than in the weaving sector, with noise levels of around 77 to 90 dB(A), and dust and vibration emissions are a rarity. More problematic are the slip agents applied to the yarn which, as in the case of the warp sizes, only appear at the textile finishing stage, where they pollute either the wastewater (from washing) or the waste air (in thermofixing).

2.4 Textile finishing

In contrast to textile production, noise plays only a very minor role in textile finishing. On the other hand odour emissions are generated from drying and thermofixing processes, and particularly wastewater pollutants, which transfer into the water during cleaning and the various textile finishing processes. The textile finishing industry both consumes relatively large quantities of water and generates large quantities of wastewater.

Only general comments can be made about water consumption in the finishing stage (see table 1), as this is determined not only by the type of fibres processed, but also by the article, type and extent of finishing, as well as the technology applied (continuous/discontinuous process) and batch size structure. For the textile finishing industry in the Federal Republic of Germany the latest figures of the TVI-Verband for 1988 set the specific water consumption at 120 l/kg goods (3).

***Table 1* - Water consumption in the textile industry (amended per (1))**

Fibre type/make-up		Mean water consumption in l/kg material
a)	by fibre type	
	cotton	50 - 120
	wool	75 - 250
	synthetic fibres	10 - 100
b)	by make-up	
	flock/yarn	100 - 200
	knit	80 - 120
	printing	0 - 400

2.4.1 Wastewater contamination

If textile finishing mills are sited in the catchment area of efficient municipal sewage works, textile wastewater should preferably undergo mechanical biological treatment before being fed to these works and discharged into the drains (indirect discharge). If this option is not provided, and the wastewater therefore has to be discharged directly into the drains, it must first be treated in the mill's own treatment plant to meet legal requirements (direct discharge). (For more detailed information on the requirements applicable in Germany, see 3.3).

Although most of the substances in the wastewater are biodegradable, discharges into open

drains can in some circumstances, during the biological decomposition stage, reduce the oxygen content of the drain water to below the level required for a healthy water quality and lead to fouling of the water.

The textile finishing industry also uses a range of compounds which are not biodegradable per se.

Below, we look briefly at the following types of wastewater pollution:

For dyes and many surfactants which do not degrade readily (but which are increasingly being replaced by more easily biodegradable ones), the said mechanical biological treatment is inadequate if there is insufficient biomass to absorb the dyes (the bonding of excess sludge to bacterial protein is the principle method by which water-soluble dyes are eliminated, see also 3.3). Past experience has shown that a combination of physico-chemical and biological wastewater treatment is required in most cases to achieve a satisfactory treatment level, with a facility for treating heavily polluted partial flows (e.g. dye liquor) separately.

Settleable solids

The values normally found in the wastewater relating to settleable solids are subject to enormous fluctuations; they are dependent on a number of factors such as finishing process, fibre type, fibre make-up and whether batch or continuous treatments are used. Sometimes the undissolved substances remain in suspension and cannot simply be filtered off. Most

values should be below 50 ml/l.

Heavy metals

The pollution of textile wastewater with heavy metals is limited by the current state-of-the-art. Cadmium is hardly ever present and mercury is present only insofar as it is introduced via soda lye and hydrochloric acid (manufactured with mercury electrodes). Chromium, cobalt and copper may penetrate the wastewater from a number of dyeing processes, and zinc from more sophisticated finishing processes (wash and wear cotton articles) (zinc in the lower milligram range, the others mostly under 1 mg/l).

Hydrocarbons

Hydrocarbons are more serious pollutants. They derive mainly from yarns which are coated with oil to give them the right slip properties, and to a lesser extent from the residues of sizing agents (impregnation).

Organic halogen compounds

Other serious pollutants are chloro-organic compounds. The AOX total parameter (adsorbable organic halogen compounds) introduced for wastewater covers a spectrum of substances which are hardly comparable in terms of their ecological and toxicological properties (highly volatile chlorinated hydrocarbons, PVC, non-toxic green pigments, toxic chlorophenols etc.).

Sources for the AOX total parameter are primarily chlorinated bleaches, anti-felting finishing of wool, dye accelerators (carriers) used to dye synthetic fibres, chlorinated reactive dyes and solvent soaps with solvents from the chlorinated hydrocarbon range (per), which are incidentally also used as the sole "dry cleaning" agent for degreasing polyester articles.

The number of compounds used which are regarded as particularly environmentally pollutant has already fallen considerably. Whereas up to 5% carrier (colour accelerators for polyester fibres), based on product weight, was previously used, dyeing is now carried out mainly in high-pressure installations where only around 0.5% carrier is needed, basically as a precautionary measure, and even then only aromatic ester-based substances are used.

Pentachlorophenol (PCP), formerly used occasionally as a preservative for heavy fabrics, has been banned since 1986. However, products of a similar composition are used with native fibres, frequently from the range of pesticides manufactured; examples of such products are chlorinated phenoxyacetic acids, hexachlorocyclohexane, DDT and allied substances.

Surfactants/detergents

An equally serious pollution problem is posed by surface-active agents, called surfactants or detergents, which are used as washing, emulsification and wetting agents, as adjustment agents for dyeing processes, as auxiliaries to improve smoothness and softness and for a range of other purposes, and to a far larger extent as dyes, and which in some cases are not fully biodegradable either. However, in the Federal Republic of Germany and other central

European countries, a minimum 80% degradability under the conditions prevailing in treatment plants is required for products used specifically as washing agents. Since this ban has been imposed there has been a definite improvement in water quality.

Surfactant water pollution is due not only to its organic load, but also its surface-active action, which on the one hand hampers the self-purifying capacity of rivers and on the other causes problems for the micro flora and fauna, and fish.

Colour

Water-soluble dyes are a further environmental pollutant specific to the textile finishing industry. If heavily coloured - something which cannot generally be determined in textile effluent after biological treatment - the light reaching plants is reduced. If wastewater from dyeing plants constitutes 20% or less of the municipal wastewater to which it is added, a mechanical biological treatment plant is generally able to bind this dye content to the excess sludge (by a sort of dyeing process) and then degrade it in the digestion tower.

Where this is not the case, substantial quantities of dye may pass through the treatment plant into the outlet and cause a perceptible coloration of the drain water.

Now that certain limit values for the density of colour of textile wastewater have been specified in *Anhang 38* (appendix 38) of the *Rahmen-Abwasser-VwV* [General Administrative Framework Regulation on Wastewater], this wastewater now requires additional decolouring

in some cases.

A partially anaerobic treatment stage, comprising the addition of ferrous (II) salts in conjunction with lime, active carbon biology and, more recently, processes using membrane technology (ultra-filtration, reverse osmosis) have proved to be effective processes. In special cases, partial dye recovery and process water recycling are possible in conjunction with membrane technology.

Water temperature

Wastewater temperature is another major form of pollution. In dyeing processes, so much hot water is discharged that, in the absence of any counter-measures, total wastewater temperatures may exceed 40C, even though 35C is the maximum permissible temperature. In many cases this heat can be recovered in heat exchangers, then returned to the process.

pH

A pH of between 6 and 9 is prescribed for wastewater discharged from treatment plants in the Federal Republic of Germany, as in most other European countries.

Because partially acidic and partially alkaline wastewater is produced in the mill, according to the treatment stage and process, a balancing tank to hold around 50% of the daily wastewater quantity is normally required by the approving authorities. Following a partial mutual

neutralisation of the various flows, the wastewater is routed from here to the wastewater plant at a fairly balanced pH and at a constant quantity.

While wastewater from wool processing plants generally has excess acidity, which requires to be buffered with alkali, the pH of wastewater from cotton processing plants is usually in the alkaline range. In this case the simplest, and at the same time, most environmentally friendly method of neutralising the wastewater involves the use of flue gas.

Major incidents

In principle major incidents may only be expected as a result of negligence, and a useful preventive measure is to appoint an "industrial water pollution control officer".

In some of the German Federal states, *Abwasser-Eigenberwachungsverordnungen* [*AbwEV* - wastewater self-monitoring ordinances] have been issued which oblige businesses in the textile finishing industry to fit control and measuring installations to keep an internal record of certain wastewater parameters and to report major incidents (27).

2.4.2 Gas and steam emissions

Gas and steam emissions are generated by textile finishing processes when fumes penetrate the exhaust air during the dyeing and drying operations, although these more general operations do not present any real environmental pollution hazard. Table 2 provides an

overview of the main sources of exhaust air emissions in textile mills.

Exhaust air from the thermofixing of synthetic fibre articles is not only more unpleasant but also more noxious, for it entrains oligomers of fibres and fragments of smoothing agents (including ethylene oxide) which may constitute up to 0.2% of the weight of the goods. Heat recovery installations - which are a must in all cases for energy reasons - arrest a considerable proportion in the form of a fatty condensate, but these substances nonetheless penetrate the wastewater during the cleaning operation (high-pressure cleaners).

Formaldehyde, which makes the eyes water and irritates the skin, may be produced in connection with the high-grade finishing of cotton articles, but formaldehyde pollution has been dramatically reduced with the introduction of modern, low-formaldehyde, etherified products, which were also required due to the effects on pregnant women.

In Europe, an increasing number of plants are resorting to thermal and/or catalytic afterburning to treat exhaust air from tenters, and all organic substances are therefore combusted to form CO_2, CO and NOx.

A further source of gas and fume emissions are coating installations, which yield solvents. There is a simple remedy - provided that chlorohydrocarbons are not used - that of elimination via the combustion air in the boiler plant.

In Germany, the requirements of the *2. BImSchV* [Second Ordinance on the Implementation of

the Federal Immission Control Act] apply to all the above-mentioned emissions. The plants concerned must be monitored on the basis of emission measurements.

2.4.3 Noise emissions

No significant noise is emitted in the textile finishing industry other than from the ventilation units commonly found elsewhere.

2.5 General impacts on the environment

In addition to textile-specific emissions which are the real object of this brief, forms of environmental pollution which are also found in many other branches of industry can occur.

Furnace installations

Thermal energy consumption is relatively high, particularly in the finishing stage (~ 13 kWh/kg goods). The firing power from the boiler plant required for process heat (steam, hot water) and for space heating usually lies within the range of 6 - 10 MW (9 - 15 t steam/h). Moreover, because of the high energy efficiency in plants which need power and heat energy simultaneously, power/heat couplings are used. The environmental brief Thermal Power Stations contains further environmental information about these installations.

Water treatment plants

A certain quality of process water (i.e. it must not contain iron or manganese, it must be not very hard but must be clear) is required for textile finishing (washing and dyeing processes) - a quality which is not often attained in surface, spring or tap water. The rinsing wastewater deriving from regeneration in treatment plants generally has a high salt content and must be fed to partial or complete treatment plants with the process wastewater.

Traffic

Goods traffic: The large material turnover results in a constant stream of goods traffic for supplying raw materials, taking away finished goods and for transport within the plants from one processing stage to another.

Passenger traffic: Textile factories often operate a two to three shift system, and times of shift changes can result in traffic jams and other problems.

Reference is made to the environmental briefs Planning of Locations for Trade and Industry, and Transport and Traffic Planning, for information on environmental impacts and environmental protection measures.

Socio-economic and socio-cultural factors

These days, plants for cloth manufacture, i.e. the textile production stages of spinning, weaving, knitting and finishing, are capital intensive operations. (In contrast to subsequent

processing in the garment industry, where the wage bill accounts for a high proportion of costs.)

The high capital input means that the machines must run, especially in the spinning and weaving sector, in 3-shift and sometimes even 4-shift operation around the clock, and in many areas at the weekend too. In an average vertical operation, i.e. with a spinning mill, weaving mill and finishing section, and with a production of about 6 million running m/year, about 300 people are now employed in three shifts in industrialised countries.

The proportion of women employed has declined sharply, but traditional family structures are nonetheless greatly affected by multiple shift operation. Furthermore, the personnel structure has been moving in the direction of trained industrial workers, and constant further training is necessary even for supervisory personnel.

The legislative framework and options for the enforcement of provisions in individual countries have a substantial influence on the impacts a textile mill has on the environment.

On the one hand there are statutory regulations and their enforcement for clean water, air and soil and for the rational use of energy, and on the other there are regulations to meet the requirements of the employees in terms of working conditions. Due mention should also be made of environmental and industrial safety provisions which are inadequate or simply do not exist, excessive working hours, low pay levels and child labour. These factors all have an influence on the quality of life of those directly affected, and the economic situation of the

textile industry generally.

[Contents](#) - [Previous](#) - [Next](#)

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

---

3. Notes on the analysis and evaluation of environmental impacts

[Contents](#) - [Previous](#) - [Next Volume](#)

3.1 Air pollution control

Over a long period the fine dust in cotton mills can trigger damage to the respiratory tract and the lungs, resulting in a disease called byssinosis. For this reason industrial countries prescribe maximum dust concentrations, but these vary from country to country and are also measured and assessed by different methods (maximum occupational limits - MAK values) in the FRG and the OSHA rules in the USA), e.g.:

- Germany, Switzerland : 1.5 mg per m^3 total dust content

- USA, Australia : 0.5 mg per m^3 fine dust

Netherlands : 15 m in the preliminary works 0.2 mg per m^3 fine dust in the spinning mill

- Great Britain : 0.5 mg per m^3 total dust
- Sweden : without fibres.

In Germany, the TA-Luft [Technical Instructions on Air Quality Control] (2) applies to the operation of furnace plants, and more recently also to drying plants (tenters), i.e. there is an approval obligation. Similar regulations apply in some other European countries too.

For other mostly gaseous substances which constitute a health hazard, the occupational limits of the Deutsche Forschungsgemeinschaft (German Research Foundation) are applicable.

***Table 2 -* Main sources of waste air emissions in textile finishing operations**

Process/make-up Substrate	**Substances emitted**	**Comment/counter-measure**
Drying and thermofixing of textured synthetic products in their washed state	Mineral oil components from vaporising flushing oils	For washed goods, approx. 0.3% of the weight of the goods, due to the residual fat content of the products. Discharge purification for high loads from:

		cooling and aerosol separation, air scrubbing or thermal afterburning.
Disperse dyeing at atmospheric pressure	Carriers (aromatic halogen compounds)	Move to closed HT plant and thermosol process (without carrier) usually possible. Can be removed by powerful scrubbers or thermal afterburning.
Drying and fixing after printing	Heavy benzene components from emulsion concentrations of the pigment print process	Largely forced out by benzene-free swelling agents. Removal by activated carbon filters or thermal afterburning.
Drying and fixing after dyeing and after a water-repellent finish	Fumes and smells (cationic softeners, some dyes etc.), paraffins	Particularly where high temperatures are used (thermosol process), organic substances may evaporate or sublimate. Can be partially removed by air cleaning with chemical additives which have an absorptive action.
Drying after a synthetic resin finish (melamine, amino-formaldehyde	Formaldehyde	Physiologically harmful, but hardly a problem these days thanks to low-formaldehyde wetting agents. Only used for a

preliminary condensates)		few articles.
Drying after solvent treatment	Solvents included	In pre-cleaning, secondary cleaning and print post-treatment processes. To be removed by condensation and activated carbon filters.

3.2 Noise protection

Noise is a serious problem in spinning and weaving mills. As mentioned earlier in section 2.2, sound levels of 70 to 110 dB(A) are commonplace.

In Germany, guideline no. 2572 of the German Association of Engineers VDI (Gerusche von Textilmaschinen), must generally be complied with (25).

Today, to prevent any adverse effects on health, individual hearing protection (ear plugs, ear muffs) must be provided from 85 dB(A) and are essential from 90 dB(A), according to the ordinance on workplaces *Arbeitsstttten-Richtlinien* and VDI guideline 2058, sheet 2.

Because of building insulation, which is standard and indeed compulsory (VDI 2571) today, external sound propagation is relatively low. Where other facilities are close by, DIN standard 18005 applies in Germany (23). The minimum distance of textile manufacturing plants from residential accommodation is established in North Rhine Westphalia in the so-called

Abstandserla **[distance decree] of the Minister for Employment, Health and Social Affairs (Minister fr Arbeit, Gesundheit und Soziales - 26).**

3.3 Water pollution control

Wastewater pollution parameters

The substances found in wastewater are classified by the proportions which can be precipitated and those which can be oxidised biologically or chemically. Chloro-organic compounds and toxic substances are also taken into account to a certain degree, e.g. some heavy metals used in textile finishing.

Anhang 38 **[Appendix 38] of the** ***Allgemeinen Rahmen-Abwasser-VwV*** **[General Administrative Framework Regulation on Wastewater] for textile production and finishing (5) applies to the textile processing industry in the German Federal Republic. It contains a range of wastewater requirements throughout the treatment plant which may not be achieved by dilution or mixing.**

The main contamination parameters are described briefly below.

For indirect discharges, state-of-the-art requirements apply, and for direct discharges the requirements of the generally accepted codes of practice also apply.

The draft of the said Anhang 38 of the Allgemeinen Rahmen-Abwasser-VwV specifies, for example, (6) the following requirements for wastewater discharged from textile mills (with the exception of water from raw wool washing, cooling systems, stencil plate production and chemical cleaning (dry cleaning) which are covered by special provisions).

- requirements according to the generally accepted codes of practice (additional for direct discharges)

COD 160 mg/l ammonium nitrogen 10 mg/l
BOD_5 25 mg/l aluminium 3 mg/l
iron 3 mg/l total phosphorus 2 mg/l

- requirements per the state-of-the-art (for direct and indirect discharges)

Cu 0.5 mg/l AOX 0.5 mg/l
Cr VI 0.5 mg/l HHHC 0.1 mg/1
Ni 0.5 mg/l free chlorine 0.3 mg/l
Pb 0.5 mg/l HC 15.0 mg/l
Zn 2.0 mg/l sulphide 1.0 mg/l
Sn 2.0 mg/l sulphite 1.0 mg/1
TF dilution factor of 2
Colour: yellow 436 nm 7m - 1
red 525 nm 5m - 1

blue 620 nm 3m - 1

- General requirements

temperature max. 35C at the point of discharge
pH 6 - 9 at the point of discharge
settleable solids 1.0 ml/l after 0.5 h settling time
odour no unpleasant odours
colour no visible discoloration of the wastewater

Abbreviations:

- **COD chemical oxygen demand**
- **BOD_5 biochemical oxygen demand in 5 days**
- **TF toxicity to fish**
- **AOX adsorbable organically bound halogen**
- **HHHC highly volatile halogenated hydrocarbons**
- **HC hydrocarbons**
- **EDTA ethylenediaminetetraacetic acid**
- **NTA nitrilotriacetic acid**
- **PVP polyvinylpyrrolidon**

The following substances, mixtures etc. may never be discharged as wastewater or with

wastewater:

- **chromium VI compounds from the oxidation of sulphide dyestuffs**
- **chloro-organic carriers**
- **halogen-organic solvents**
- **arsenic and mercury and their compounds from use as preservatives**
- **pollutant concentrates, such as residual sizes, residual high-grade finishing agents, print pastes, dye preparations, residues of chemicals used, textile auxiliaries and dyes from drums**
- **surfactants which do not meet the requirements of the WRMG [law relating to the environmental compatibility of washing and cleaning agents] (22).**

All these substances must be collected, recycled where technically feasible or disposed of correctly.

For partial wastewater flows, particularly from the following departments: desizing, bleaching, printing, dyeing, finishing, coating and backing, together with central barrel and drum cleaning, threshold values apply above which treatment is required. If various processes are carried out consecutively in a single mechanical unit, the wastewater from each must be dealt with as a partial flow.

Threshold values for partial wastewater flows beyond which treatment is required:

AOX 3.0 mg/l Cr 2.0 mg/l
HHHC 1.0 mg/l Cr VI 0.5 mg/l
HC 50.0 mg/l Zn 10.0 mg/l
Cu 2.0 mg/l Sn 10.0 mg/l
Ni 2.0 mg/l

The AOX threshold value for bleaching with chlorine to obtain a particular shade of white and the non-felting finishing of wool is 8 mg/l (up to 31.12.1996 max.).

All analyses and measuring procedures required to determine the said pollutants have now been standardised in Germany to DIN.

***Table 3* - Measuring procedures for wastewater parameters in the wastewater treatment plant**

Parameter	Method
- Filterable substances - Settleable substances - Chemical oxygen demand - COD - of the precipitated sample - Biochemical oxygen demand - BOD_5 -of the precipitated sample - Toxicity to fish as TF dilution factor of the unprecipitated sample	DIN1 38409-$H_{2-2/3}$(July 80 edition) DIN 38409-H_{9-2}(July 80 edition) DIN 38409-H_{41}(December 80 edition) DEV2 H_5A_2 (4th issue 1966) with additional restriction on nitrification at 0.5 mg/l

- Zinc, copper, chromium - Nitrogen from ammonium compounds from the unprecipitated homogenised sample - Effective chlorine from the filtered sample - Sulphide, total, from the unprecipitated sample - Sulphite, total, from the unprecipitated sample - Hydrocarbons from the unprecipitated homogenised sample	DIN 38412-L_{20}(December 80 edition) DIN 38406-E_{21}(September 80 edition) DEV E5.2(7th issue 75) DEV G_4 1.b (7th issue 75, glassfibre filters) DEV D 7b(7th issue 75) DEV D 6.2(1st issue 60) DIN 38409-H18(February 81 edition)

[1] DIN = German Standard

[2] DEV = Deutsches Einheitsverfahren (German standardisation procedure)

4. Interaction with other sectors

While, on the raw materials side, the textile industry has close connections with plant production (natural fibres), the fibre industry (synthetic fibres) and the chemical industry (chemical, dyes, auxiliaries), its activity on the sales side is characterised by its interaction with

the clothing industry downline.

Further references to relevant project areas are given in the text.

5. Summary assessment of environmental relevance

In investment projects in the textile industry sector a range of environmentally relevant criteria must be taken into account at the location planning stage. In raw material producer countries in particular special consideration must be given to the effects of material production. The early and full involvement of the population groups affected, particularly women in some cases, can help resolve any problems which may arise.

Special attention must also be paid to the environmental impacts of raw wool washing and textile finishing plants. While in the former the problem is posed by the considerable degree of wastewater contamination, in textile finishing mill projects due account must be taken of the high water and energy consumption, the wide use of chemicals, the process-specific pollution of wastewater and exhaust air and the disposal of waste. In this regard, special industrial environmental protection officers must be appointed.

The current state-of-the-art in the processes, process installations and supply and disposal plants, together with relevant laws and their enforcement, combine to ensure that thoroughly

environmentally sound textile production is possible at all stages of manufacture.

With regard to the socio-economic environmental impacts of textile projects mention should be made of the much more stringent requirements relating to personnel qualification. The capital-intensive nature of modern, extensively automated spinning, weaving and knitting mills is leading to the maximisation of machine operating times, thus multi-shift operation, usually 7 days per week, is the norm.

The whole area of socio-economic and socio-cultural aspects of this type of operation and its legislative framework must be looked at carefully.

6. References

1. Dring, G.: VDI-Berichte, Nr.310, 1978.

2. Technische Anleitung zur Reinhaltung der Luft - TA-Luft of 27.02.86; Gemeinsames Ministerialblatt GMBI 1986.

3. Year books for 1988 and 1990 of the Gesamtverband der deutschen Textilveredelungsindustrie, TVI-Verband EV.

4. 83. Allgemeine Verwaltungsvorschrift ber Mindestanforderungen an das Einleiten von Abwasser in Gewsser (Textilherstellung) - 38. AbwasserVwV - of 5 September 1984, GMBI (joint ministerial circular) 1984.

5. Anhang 38 to the Allgemeinen Rahmenabwasserverwaltungsvorschrift fr die Textilherstellung - Draft of 20 December 1990.

6. Dr. Heimann, S.: Textilhilfsmittel und Umweltschutz; Melliand Textilberichte, 7/1991.

7. Natke, H.G., Thiede, R., Elmer, K.: Curt-Risch-Institut fr Dynamik, Schall- und Metechnik, Universitt Hannover: Untersuchungen der von Webereien ausgehenden Schwingungsemissionen und Hinweise zur Websaal-Bauplanung. Verband der Nord-Westdeutschen Textilindustrie Mnster; Zeitschriftenreihe, Heft 66, 1985.

8. Trauter. R.: Rckgewinnung und Wiedereinsatz von Webschichten mittels dynamisch geformter Membranen; Chemiefasern/Textilindustrie 37/89, 1987.

9. DIN 38409-H14-H14: Deutsche Einheitsverfahren zur Wasser-, Abwasser- und Schlamm-Untersuchung: Bestimmung der adsorbierbaren organisch gebundenen Halogene (AOX).

10. 2. Verordnung zur Durchfhrung des Bundes-Immissionsschutzgesetzes (Verordnung zur Emissionsbegrenzung von leichtflchtigen Halogenkohlenwasserstoffen - 2 BImSchV of 21 April 1986); BGBI (Federal Law Gazette) 1986, Part 1.

11. Kolb, M., Funke, B.: Die Entfrbung von textilem Abwasser mit Fe(II) + $Ca(OH)_2$; Vom Wasser, Bd. 65, 1985.

12. Wysocki, G.; Hke, B.: Chemie-Technik, 1974.

13. Oehme, Ch.: Trgerbiologien in der Abwassertechnik; Chem.-Ing.-Tech. 56, 1984.

14. Croissant, B.: Efferenn K.; Frahne, D.: Reaktivfarbstoffe im Abwasser - sind sie durch ein bakterielles Symbiosesystem abbaubar? Melliand Textilberichte, 1983.

15. Erla ber Richtlinien fr die Anforderungen an Abwasser bei Einleiten in ffentliche Abwasseranlagen of 28 June 1978.

16. Wiesner, J.; Jochen, E.: Energieverbrauch und Mglichkeiten rationeller Energienutzung in der Verarbeitenden Industrie in Baden-Wrttemberg: Textilindustrie, Informationen zur Energiepolitik, Heft 11c, Wirtschaftsministerium von Bad.-Wrtt., Stuttgart, 1978.

17. Reetz, H.: Europische Abwasserregelungen im Vergleich; Melliand Textilberichte, 11/1991.

18. Christ, M.: Wrmerckgewinnung und Abluftreinigung bei der Textilveredlung; Textilpraxis International, 46/1991.

19. nderung der 4. BImSchV Nr. 5.3 - Genehmigungspflicht fr Anlagen der Textilveredlung und

von Feuerungsanlagen.

20. "Wastewater purification" working party J. Janitza, S. Koscielski, M. Schnabel of the ITV (Institut fr Textil- und Verfahrenstechnik Denkendorf) Behandlung von Textilabwssern im Betrieb; Textilpraxis International, November 1991.

21. Gesetz zur Ordnung des Wasserhaushaltes (Wasserhaushaltsgesetz - WHG) of 23.09.1986.

22. Gesetz ber die Umweltvertrglichkeit von Wasch- und Reinigungsmitteln of March 05, 1987.

23. DIN 18 005; Schallschutz im Stdtebau, Planungsrichtlinien.

24. VDI 2058; Beurteilung von Arbeitslrm am Arbeitsplatz hinsichtlich Gehrschden.

25. VDI 2571 + 2572; Schallabstrahlung von Industriebauten.

26. Abstandserla (RdErl. d. Ministers fr Arbeit, Gesundheit und Soziales NW of March 09, 1982).

27. Verordnung zur Eigenberwachung von Abwasser, Bayern (AbwEV) of December 09, 1990.

28. ITMF; International Textile Manufacturers Federation - International Textile Shipment Statistics, Vol. 14/1991.

29. World Bank; Environment Guidelines; Washington 1988, p.451 ff.

Contents - Previous - Next Volume

Contents - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

---

1. Introduction

1.1 Objectives and terms of reference

The Compendium of Environmental Standards (CES) contains information about environmental standards that can be drawn upon for the purpose of estimating and evaluating projects' environmental impacts.

In its present form this volume already constitutes a source of basic information about a variety of specific standards. However, the number of standards described in full and the scope of the related information are still limited. This compendium should thus not yet be regarded as exhaustive, but rather as a manual still in the process of being compiled. It is structured so as to permit both the addition of further information to existing sections and the inclusion of new sections. The modular structure, the overall design and the design of the individual sheets will allow the work to be updated and supplemented as required.

1.2 Environmental standards

The term "environmental standards" refers in the broader sense to parameters, indicators and classification systems which can be used to monitor impacts on the environment, describe environmental quality or determine elements of these. In the narrower sense of the term, "environmental standards" can be taken as meaning

- **parameters that can be used in formulating limit values, recommended values or other environment-related measurands, or**

- **the actual limit values, recommended values or specifically function-oriented measurands (limit values, recommended values, guide values, ecotoxic measurands etc.).**

Environmental standards can relate to any element of the complex of ecological

interrelationships and may be classified as pertaining to the individual components:

- **Atmosphere (the envelope of air surrounding the Earth)**
- **Pedosphere/lithosphere (the soil covering the Earth/the Earth's crust)**
- **Hydrosphere (the aqueous vapour of the entire atmosphere and that part of the Earth's surface consisting of water)**
- **Biosphere (the Earth's life zone; habitat of flora and fauna)**
- **Anthroposphere (man's life zone; human habitat)**

The operational starting points for standards are generally derived either from the type of influence exerted on the environment or from the requirements to be fulfilled by elements of the environment:

Influence categories

Standards pertaining to the release/discharge of pollutants/noise/heat and the use of environmental media (influences on the environment) relate to impacts originating directly from the projects under consideration.

1 Waste water: discharge of contaminated or polluted water into surface waters or into the groundwater.

2 Waste heat: discharge of heated water into surface waters or into the groundwater.

3 Emission: discharge of gases and dusts into the atmosphere; special emissions such as light, radioactivity, electromagnetic rays.

4 Solid wastes: production and dumping of waste materials, excavated material, sewage sludge, mining waste etc.

5 Chemical aids: introduction of chemicals into the environment for a specific purpose (e.g. pesticides and fertilisers, thawing salt etc.).

6 Changes in land-use: changing the existing surface cover or changing the purpose for which an area of land is used.

7 Removal of soil: elimination or relocation of the biologically active soil cover.

8 Action influencing the water balance: (quantitative water management); influencing or use of the available water supply for a specific purpose.

9 Action influencing the surface configuration: changes in orographic conditions (excavation and deposition); changes in the landscape.

10 Noise emission: emission of noise (outside enclosed spaces).

Environmental quality categories

Standards pertaining to environmental quality relate to elements and functions of the environment that are the subject of direct user requirements.

1 Air quality: requirements in respect of air purity and other parameters, e.g. as imposed by immission limit values.

2 Climatic situation: requirements in respect of the topoclimate in particular.

3 Noise situation: requirements in respect of absence of noise.

4 Available water supply: water needs (quantitative aspect).

5 Water quality: requirements in respect of water purity and condition/absence of harmful, undesirable substances, microorganisms and other parameters.

6 Soil quality: requirements in respect of the (physico-chemical and biological) condition of the soil.

7 Agricultural and forestry land: requirements in respect of land that can be used for producing food, wood and other forms of biomass.

8 Special biotope functions: requirements in respect of bioecological conditions (not covered by 1 to 6 above).

9 Food quality: requirements in respect of the absence of pollutants and pathogens from food and in respect of food quality from the nutritional-physiology viewpoint.

10 Special uses and functions: requirements in respect of specific conditions (not covered by the above), e.g. recreational use, protected-area status, landscape.

Bioindicators

One question which arises in connection with environmental studies concerns the value of bioindicators. The term "bioindicators" refers to a wide variety of biological (as opposed to chemico-physical) methods for ascertaining environmental conditions. Bioindicators are used for aquatic ecosystems and feature in regulations laying down water standards. More or less standardised methods exist for ascertaining the immission or load condition of other media, although such methods are in general used on only a very limited scale in the Federal Republic of Germany. If it proves possible to develop bioindicator systems geared to practical requirements, however, it is likely that methods of this type will gain in significance.

Bioindicators impose special demands in terms of region-specific calibration and standardisation. It is above all with regard to the kinds of ecotope found in tropical zones, however, that a great deal of research, development and preparatory work is still needed before bioindicators can be regarded as ready for operational use, let alone used as standards. So far there is at any rate no compilation of bioindicators that could be used in environmental studies.

Excursus: The importance of standards

The first key task of a study for the purpose of estimating and evaluating environmental impacts is the value-free determination of a project's effects on the environment and the resultant or likely changes. However, the study cannot serve as a decision-making aid until the significance of these effects and changes has been evaluated. The criteria used in this evaluation must be derived in the final analysis from the demands which man requires the environment to fulfil, whether these be based on physiological, economic, ethical or other considerations. They are reflected among other things in the goals of the German Federal Government's environmental programme, which can be summarised as follows:

- **to safeguard health and well-being against harmful environmental influences of anthropogenic origin.**
- **to preserve and improve the efficiency and usability of the natural household.**
- **to preserve the natural diversity and characteristic features of fauna, flora and landscape.**

One way of concretising the above goals and criteria and translating them into operational terms is to formulate limit values and recommended values (referred to hereinafter as "standards"). In the past (and this will undoubtedly remain the case), every country went its own way in developing such standards with the result that there is today an immense variety of limit values, recommended values and guide values which differ not just in terms of the

absolute value given (varying by factors of up to 1000), but also with regard to the related marginal conditions such as measuring technique, reference area and reference period, averaging method, pre-existing pollution level, binding nature etc., and therefore do not lend themselves to comparison.

This situation can be ascribed not only to the difficulty of laying down standards that can be justified from the scientific viewpoint and to the resultant need to combine scientific findings, economic and political interests, available measuring and monitoring techniques, the latest state-of- the-art and so on. It also stems from the fact that basic environmental-policy concepts vary from one country to another (depending on problem urgency and problem awareness, attitudes towards the environment, economic system, political decision-making mechanisms and many other factors).

Various aspects of this problem are outlined below:

- **taking the example of cadmium, the wide variety of possible standards and the basic qualitative difference between emission standards and immission standards.**

- **taking the example of air quality management, the possible (necessary) coordinated application of different standards to achieve quality goals.**

- **possible political strategies for laying down emission standards.**

Substance-specific standards (example: cadmium)

The wide variety of conceivable standards that can apply even to pollutants whose presence is relatively easy to ascertain can be demonstrated using the example of cadmium, a heavy metal. Figure a) is a highly simplified representation of the possible pathways taken by cadmium to reach the receptor, namely man. Each of the arrows constitutes a starting point for a wide variety of standards. This example clearly demonstrates that all standards which relate to those elements in the effect complex preceding uptake of the pollutant by the receptor serve the purpose of ensuring compliance with the receptor-specific standards. They should thus essentially be derived from the receptor's requirements, which in the case of man, for example, may vary considerably from one individual to another (differing degrees of sensitivity!) and from one country to another (e.g. different eating habits). As knowledge of the chain of effect is in most cases only fragmentary, the unreliability of a standard increases in proportion to its "distance" from the receptor. It follows that emission standards involve far greater factors of uncertainty than quality standards and this also explains why for the most part they are (indeed, have to be) laid down on the basis of criteria which have little to do with the pollutant's impact on the receptor.

Fig. a): **Pathways taken by cadmium in reaching man**

Standards for air pollutants

The most sophisticated air quality management systems, such as those in the USA and the Federal Republic of Germany, employ (along with other measures) a variety of coordinated standards in order to influence various stages of processes and mechanisms that may eventually lead to unwanted immissions and impacts.

They limit or regulate

- **the composition of substances which can give rise to emissions when used for their intended purpose (product standards);**

- **the design and operation of plants, installations and equipment, with a view to minimising emissions (equipment standards);**

- **the emission of air pollutants into the atmosphere, by means of plant-specific and/or substance-specific regulations (emission standards);**

- **the atmospheric concentration or deposition of air pollutants; in this way the uptake of pollutants and their impact on specific acceptor groups are indirectly limited (immission standards , "ambient air quality standards"). As a particular pollutant may have different impacts on different acceptor groups, there may be different standards for one and the same substance.**

Political strategies for establishing standards

A variety of different strategies is adopted in laying down emission standards. This can lead to greatly differing standards for one and the same impact on the environment and to greatly differing results in terms of environmental quality:

Best available technology

This approach involves basing standards on the state-of-the-art. It demands the maximum degree of environmental protection possible on the basis of the current state-of-the-art. It may be stipulated, for example, that improvement of water quality must be directly in line with technical innovation. Aspects such as the relative toxicity of substances, the varying distribution pathways taken by substances and the capacity of the receiving water are not taken into account.

Standards laid down in this way apply in the USA, for example, to industrial dischargers:[1)]

- Plants built after 1977: "Best practicable control technology currently available"
- Plants built after 1983: "Best available technology economically achievable"
- New sources: "Best available demonstrated technology".

1)Greenwood, D.R. et al. (1983): A Handbook of Key Federal Regulations and Criteria for Multimedia Environmental Control. Research Triangle Kust., Research Triangle Park, W.C.

Uniform emission standards

Such standards limit the concentration of substances, for example in waste water, irrespective of the discharger's location.

Standards of this type are generally based on the "pollution potential" of the dischargers and/or the effectiveness of the recognised or commonly used technologies. Their advantages are that they are easy to monitor and administer and monitoring of pollution is relatively inexpensive.

The disadvantages are that the pollutant load and site of the discharge, along with the capacity and pre-existing pollution level of the surface water, are not taken into account.

Uniform standards can lead to some receiving waters becoming totally overloaded, while the natural self-purification capacity of others is at the same time not fully utilised.

Such standards exist in the form of statutory requirements or guidelines, e.g. in Singapore (Trade Effluent Regulations, 1976; Water Pollution Control and Drainage Act, 1975).

Local emission standards

This method involves laying down standards on the basis of local conditions (which does not necessarily mean environmental conditions) to achieve goals such as a specific water quality.

Advantages: Standards of this type can be updated on the basis of the latest findings and technologies; dischargers are called upon to fulfil more stringent requirements than those actually demanded by the quality goal.

Geoecological conditions and the requirements which the environment is called upon to fulfil are taken into greater account than is the case with any other method. This method is therefore often considered better than the two referred to above.

Disadvantages: Administration and monitoring are more difficult because standards may vary from plant to plant. Serious distortions of competition may occur. Standards of this type are applied in countries such as the United Kingdom.

However, differences in the values stipulated by standards cannot be ascribed solely to the use of different strategies. A role is also played by the different techniques used for performing measurements and transmitting the measured values, the statistical characteristics of the limit value (mean values, peak values, percentiles), the measurement location, etc.

One thing common to all types of standard is that compliance with them must be monitored.

A standard is not meaningful unless it can be established whether the actual level is above or below the standard and how far it deviates from the standard. However, the nature of the monitoring system plays a crucial role in determining the results obtained; different monitoring systems may arrive at totally different results for one and the same actual situation.

It follows that there are very close links between a standard and the monitoring system. Indeed, determination of a standard must incorporate stipulation of the basic monitoring principles.

Yet even if two different countries apply identical, equally well-defined standards for a particular substance, it must not be concluded that equal importance is attached to these standards, for example within the framework of the air pollution control strategy of the two countries concerned. It is thus also essential to ask, for instance, what happens when the standard is exceeded; in other words, to ascertain the philosophy behind the standards and the entire concept of air pollution control. If - to take an extreme case - nothing happens in one country, whereas in the other a plant is closed down, it is clear that the importance attached to the standards from the monitoring viewpoint is totally different even though they lay down identical values. Unless all the aspects involved in defining standards are known and taken into account, it thus cannot be concluded that a country with a low SO_2 standard pursues a tougher policy on air pollution control than a country in which a higher limit applies.

In the light of these considerations, the following points should be borne in mind when interpreting and using standards:

1. The range of existing standards is immense. It is thus neither feasible nor expedient to make a collection of all available standards. Such a collection would be the size of a small library and would not make any major contribution to achieving the goal set. Any compilation of standards that is possible and meaningful within a given context can therefore represent only a more or less arbitrary selection from such a collection.

2. A standard does not consist simply of a single figure; definition of standards calls for a wealth of information. Comparison of standards from different countries is a complex process which must be carried out with great care and requires a high degree of expertise. The standards collected thus cannot be analysed and interpreted on the basis of strictly scientific criteria, but must essentially be subjected to an interpretative appraisal, especially as the reasons for particular standards can be ascertained from the normally available documentation only through "detective work" or not at all.

This applies in particular to

- establishment of the reasons for particular standards and the related assessment of their validity (i.e. the appropriateness of their content) and their applicability to other countries;

- statistical analysis of what is often a wide range of different standards for a particular pollutant;

- recommendation of individual standards for use.

For the reasons mentioned above, it is probably virtually impossible to classify standards according to their "soundness" (i.e. their "quality" and thus their correctness/appropriateness/ reliability).

3. The collected standards and analysis of them give no indication of whether and to what extent regional geoecological conditions played a part in their formulation. On the contrary, it must be pointed out that countries with a more sensitive environment often apply higher (i.e. more generous) standards than those with a less sensitive environment. There are certain indications that the condition of the environment is more likely to play a role: a poor environmental situation may well result in generous standards being laid down, as enforcement of more stringent ones would involve unacceptable expense or would not be possible at all. Countries which have no chemical industry or lack functioning monitoring systems will have tougher standards for the same emissions, as compliance with them is ensured without the need for elaborate systems or is not monitored.

4. For fundamental scientific reasons, standards must never be regarded as limits below which there will be no negative impacts but above which the consequences will

be disastrous. Every standard is at best merely one aspect (often chosen arbitrarily and dependent on many criteria that cannot be objectivised and are often unrelated to the area concerned) in the (generally unknown) functional relationship between impact or condition and the damage caused. The use of standards as "yes/no" decision-making criteria in the administrative and legal fields (e.g. in connection with granting of trade permits or legal actions to recover damages) does not indicate, let alone substantiate, their "correctness" or justifiability on the basis of scientific criteria. Standards which are not directly receptor-oriented, particularly emission standards, cannot do more than serve as guidelines for eliminating what are clearly insignificant aspects from further study. (However, standards which relate to concentrations and not to pollutant loads are totally unsuitable for this purpose as well).

Inappropriate decisions may be reached if standards are used without explicit consideration of all the marginal conditions limiting their validity.

The frequent need to weigh competing environmental goals against each other (e.g. emission or waste water pollution?) or to weigh the claims of environmental goals against those of economic goals calls for more varied criteria and yardsticks than standards can offer.

5. Quantitative standards (lending themselves in principle to measurement and

objective monitoring) have been used hitherto for the most part to determine the presence of substances and pollutants in environmental media. They do not cover the particularly serious consequences of action taken by man to shape the environment and the effects which this may have on usable resources (and thus on the basis of economic activity) and on fauna and flora.

Given the present situation as regards scientific discussion and development of standards, it must be said that standards are at best an aid that should be used with the utmost caution in environmental studies. Under no circumstances should the decision on whether or not a project is to be implemented be made solely contingent upon compliance or non-compliance with standards.

At the same time, however, there can be no doubt that standards are an essential aid to evaluating the environmental impacts of project measures.

1.3 Structure of the compendium of environmental standards (CES)

The Compendium of Environmental Standards is based on two classification principles:

1. On the basis of the direct starting points for standards, a distinction is made between two categories:

Standards pertaining to the release/discharge of pollutants/ noise/heat and the use of

environmental media (influences on the environment) (Section 3)

Standards pertaining to environmental quality (Section 4)

Further distinctions are accordingly made on the basis of impact or source categories and aspects of environmental quality (elements to be protected, sectors of the environment, media etc.) (see matrices overleaf).

Matrix: Standards for influences on the environment

Impacts on the environment:

1 Waste water
2 Waste heat
3 Emission
4 Solid wastes
5 Chemical aids
6 Changes in land-use
7 Removal of soil
8 Action influencing the water balance
9 Action influencing the surface configuration
10 Noise emission

Here:	**Sources, measures** **Focal areas of project activities**	1 2 3 4 5 6 7 8 9 10
		- Standards/Related impacts -
Agriculture		
Forestry		
Transport (road, rail, water, air)		
Municipal water supply		
Municipal waste disposal		(Impacts of varying intensity)
Manufacturing industry		
Mining, raw-material recovery		
Hydraulic engineering measures (irrigation and drainage, etc.)		
Other (e.g. fisheries, housing, telecommunications)		

Matrix: Standards for environmental quality

Goals, receptors, elements to be protected

1 Man
2 Natural household
3 Fauna and flora
4 Cultural and material assets

Requirements in respect of environmental quality from the receptors' viewpoint relate to	**1 2 3 4**
Effects	**Requirements**
	- Standards/Related impacts -
Air quality	
Climatic situation	
Noise situation	
Available water supply	(Impacts of varying intensity/requirements of varying types and stringency)
Water quality	

Soil quality	
Agricultural/forestry land	
Special biotope functions	
Food quality	
Special uses and functions	

2. On the basis of the areas covered by existing data sources and specialist fields, it is possible to define "information categories" which can be viewed as relatively independent volumes of information. They essentially comprise the following:

Sources, measures and project activities
(Equipment, plants, planning and construction measures, source-specific standards)

Chemical substances
(Individual substances, compounds and substance groups that can be clearly defined in chemical terms)

Non-specific substance categories
(Substance groups that are non-specific in chemical/physical terms, collective

designations used in environmental planning for particular substance groups)

Parameters and indicators
(Physical or ecological measured values, parameters and indicators, with the exception of substances and substance categories)

Environmental media
(Individual parameters, standards or indicators for determining the quality of environmental media)

Acceptors and elements to be protected
(Individual parameters, standards or indicators for determining environmental quality with respect to specific acceptors or elements to be protected, excluding environmental media)

Categories or environmental subsectors used in specialised planning
(Environmental subsectors used in specialised planning)

Uses and functions
(Individual parameters, standards or indicators for determining the environmental quality of specific areas of land, forms of land-use and land functions)

International environment legislation

(EC treaties and international multilateral environment treaties)

Regulations and guidelines
(National and international regulations and guidelines, methods for controlling factors influencing the environment and for determining environmental quality)

The information categories "Chemical Substances and Groups of Substances" and "International Environment Legislation" are covered by separate sections in the CES. The information in question is compiled as registers in the form of tables, overviews and information sheets. Both classification principles reflect the potential main areas of interest, while at the same time defining the framework for further processing and for updating.

A certain degree of redundancy has been allowed for in order to enhance readability and on pragmatic grounds. For example, the text concerning "standards in the EC Water Protection Directive" is included in the section "International Environment Legislation", while the water-related standards in respect of chemical substances are in turn given with the other information on the substances in question in the section "Chemical Substances". Each of the sections is thus self-contained. Each can be seen as a source of data for the other, with a certain amount of overlap in terms of content.

Another important aspect of the overall CES concept is that the work is intended to be viewed as a manual which both provides information and draws attention to other information sources. Examples of the latter include compendiums on hazardous goods (e.g. HOMMEL,

most recent version), lists of protected species (e.g. IUCN database), compilations of chemical data (e.g. IRPTC, 1987; UN-CLP, most recent version) and compilations of legal texts (e.g. BURHENNE, most recent version). Some registers have in part been incorporated directly in the CES. Where appropriate, additional data could be included or sections combined and new registers defined.

Contents - Next

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

---

2. Guidelines for the user

2.1 Sections

The Compendium of Environmental Standards comprises

- the text section (Sections 1 to 4)

- the sections "Chemical Substances and Groups of Substances" (Section 5) and "International Environment Legislation" (Section 6)

- an annex containing general lists.

The text section sets out the general framework, as well as highlighting basic conditions and special aspects relevant to environmental standards. It provides a structured outline of the field covered, indicating components which determine the environmental relevance of project activities and factors that can serve as environmental standards or related parameters.

The main part of this volume focuses on the two information categories (see Section 1.3, Structure) of particular concern:

- Chemical substances and groups of substances
- International environment legislation

Both of these sections are structured in the same way and a similar approach should be adopted for any information categories added in later editions. The first few pages in each case contain specific explanatory notes; the subsequent register section comprises lists and tabular overviews. These are followed by information sheets giving detailed information on particular subjects such as individual substances, directives and treaties. With the aid of the

general index, each register can be consulted in the manner of an encyclopedia. The sources used and their relevance are described in detail in the explanatory notes on each section.

The titles of the general lists are self-explanatory. Particular attention must be drawn to the general index, which serves to link the individual sections and, alongside the table of contents, offers appropriate starting points for using this volume.

2.2 Seeking specific information

Specific information can be sought by looking up individual subjects in the general index (see above). For cases in which the user does not necessarily wish to approach a particular topic via a specific entry, the table on the next page indicates where in this volume further information is likely to be found.

Information categories and references

Information on:	Consult/Reference in:
Sources, measures and project activities	1. Index 2. Measure/project categories acc. to EC directive on EIA
Chemical substances and substance groups	1. See specific section 2. See search path 3. Register of substances 4. Index

	5. Bibliography and sources
Non-specific substance categories	Index
Parameters and indicators	Index
Environmental media	Index
Acceptors and elements to be protected	Index
Categories or environmental subsectors used in specialised planning	Index
Uses and functions	Index
International environment legislation	1. See specific section 2. Register of environment treaties 3. Bibliography and sources 4. Index
Regulations and guidelines	1. Bibliography and sources 2. List of international multilateral environment treaties 3. Register of EC environment treaties 4. Index

Search path for locating information on a chemical substance/group of substances

Sought: Name of a chemical substance or substance group	

Question	Name found/Reference
A.	Does the CES contain detailed information on the substance?
	1. Index Contains the substance name in its commonly used form; if not found there:
	2. Index to register of substances with most important common names and synonyms Contains substance name and indicates a) principal name for information sheet b) principal name in the table "Chemical substances of environmental relevance arranged according to selected laws and guidelines; also list of information sheets in register of substances"
	3. Table: Chemical substances of environmental relevance arranged according to selected laws and guidelines; also list of information sheets in register of substances Indicates among other things whether the substance is covered by an information sheet
B.	Is the substance listed in the

	EC Directive on Water Protection (most recent version) soil conservation concept of the Federal Government (most recent version) Technical Instructions on Air Quality Control *TA-Luft* (most recent version)?
	1. Table: Chemical substances of environmental relevance arranged according to selected laws and guidelines; also list of information sheets in register of substances Contains all substances featured in one of the three sets of provisions
C.	Is the substance included in the Catalogue of Substances Hazardous to Water (most recent version) list of maximum workplace concentrations (MAK) (most recent version)?
	1. If it is also featured in the provisions referred to under B. above: Table: Chemical substances of environmental relevance arranged according to selected laws and guidelines; also list of information sheets in register of substances
D.	Was the substance name not found or is more detailed/specific information required?
	1. Bibliography and sources (comprehensive updated standard works are highlighted in bold type)

Contents - Previous - Next

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

3. Standards for influences on the environment

3.1 Waste water

3.1.1 General

The term "waste water" refers to water entering the sewerage system in the form of water whose character has been changed as a result of domestic or industrial use (particularly water which has been polluted in some way) and rainwater run-off from developed land. It also includes water contaminated as a result of agricultural use and water issuing from dumps.

The harmfulness of waste water is determined by specific properties which (both individually and together) can change the quality of a body of water. These include

- **the content of the water in respect of particular substances (concentration)**
- **the pollutant quantity discharged into the water within a specific period (pollution load)**
- **certain properties and effects of the waste water (e.g. oxygen depletion).**

Discharge of waste water into surface water may impair the quality of the latter, i.e. it may cause contamination or lead to other adverse changes in the water's physical, chemical and biological properties. Emission standards are used in monitoring waste water at the discharge site; they are intended to preserve the water quality necessary for various forms of use and to protect aquatic organisms.

Existing standards for the constituents of waste water apply to

- discharges into sewerage systems with sewage treatment plant and/or

- discharges into bodies of water and into sewerage systems without sewage treatment plant.

Emission standards essentially aim to ensure that waste water is pretreated or the pollution load reduced before waste water is discharged into surface waters.

Waste water disposal regulations, which are generally laid down in national water protection legislation, are backed up by guidelines or minimum requirements concerning discharge of waste water into surface waters. Waste water pretreatment is usually required whenever the monitoring value concerned is frequently and significantly exceeded in the untreated waste water at the point of discharge.

However, it is not always reasonable or feasible for industrial and municipal dischargers to realise waste water treatment measures, for example on account of the degree of treatment-plant utilisation, extent of connection to treatment plants, frequency of sampling etc.

The regulations governing the constituents of waste water require that maximum concentrations not be exceeded (mg/l, μ g/m^3, mmol/m^3). Standards in industrialised countries are laid down in line with "recognised engineering practice" or the like, which is based on specific waste water treatment methods rather than local conditions, the volume of waste water produced or the capacity of the receiving water.

Emission standards may be modified on the basis of

- **the purpose for which a body of water is predominantly used**
- **the ratio of discharge to gravitational flow into receiving water**
- **directives issued by local authorities.**

Measuring procedures for determining the flow and constituents of waste water relate to constituents relevant to water quality on account of the size of the pollution load which they represent or because of their specific harmfulness. Apart from overall limits in the form of summation parameters (settleable solids, BOD_5, COD, toxicity to fish), particularly harmful substances or substance groups must be covered individually (e.g. dissolved metals, organic halogen, phosphorus or tin compounds, carcinogenic substances). A distinction must be made between general qualitative standards in the form of discharge bans (or restrictions) and parameter-specific standards.

3.1.2 Project activities

1. Agriculture

Agriculture generates waste water on account of the activities involved in the production of feed, meat and milk. Agricultural waste water essentially comprises the following:

- **Liquid manure**

- Silo seepage water
- Whey
- Livestock farming wastes
- Waste water from irrigation

2. Transport

The major types of waste water originating from the transport sector are the waste water discharged directly during construction and operation of transport systems and the pollutants contained in rainwater run-off.

3. Municipal waste water disposal

Municipal waste water comprises the waste water from residential areas and towns which is collected and removed by a system of channels or pipes. It stems primarily from

- households
- facilities such as hostels, hotels, hospitals and authorities
- refuse incineration plants
- small industries
- surface run-off
- sanitary landfills

and may enter the receiving water either directly or following treatment.

Municipal waste water discharges are characterised by considerable fluctuations in terms of composition (washing water, bathing water, slop water and faecal water), quantity and time of discharge. Domestic waste water contains suspended matter, sludges, colloids and dissolved substances such as urine, salts and detergents. These substances contain oxygen-depleting constituents which are fairly readily degradable and are therefore likely to putrefy if there is an oxygen shortage.

Sewerage systems for residential areas may take the form of separate or combined systems. In the former the sewage and the rainwater run-off are removed in separate sewers, while in the latter system they are removed together. Depending on the frequency, duration and quantity of overflow, some of the waste water may enter surface waters without passing through the treatment plant if there is increased run-off on account of wet weather. Substances deposited in the sewer during periods of dry weather are picked up again on account of the increased tractional force resulting when flow is heavy and may reach concentrations far in excess of the original discharge concentration. Separate systems too can cause sizable pollution loads to be carried into the receiving water by the rainwater.

An analysis of standards shows that in many countries direct discharge of waste water from residential areas into surface waters requires a special permit or is banned altogether. In the vast majority of cases, such qualitative standards apply in countries where legislation on

water pollution control is in force. The relevant EC directives can be taken as a yardstick (see separate section).

4. Energy supply

Waste water from energy supply facilities essentially consists of process water (generally cooling water) contaminated with biocides. Such substances are used to maintain water purity, remove algae from the water and protect the cooling system. Particular attention must be drawn in this connection to chlorine and chlorine compounds (see Register of Substances).

5. Manufacturing industry

Industrial waste water comprises contaminated water which has been used as a raw material, solvent or means of transportation, for cleaning, sanitary purposes and the like.

Industrial waste water

- often has a one-sided composition, i.e. specific groups of chemical substances predominate;

- contains inhibiting, non-degradable and toxic substances;

- is subject to considerable variations in composition and concentration;

- contains substances which, for example as a result of bacterial conversion, may be a primary or secondary source of considerable odour nuisances.

On the basis of the above-mentioned properties, industrial waste water is often subdivided into

- waste water which can be discharged into the sewerage system or into surface waters without reduction or pretreatment

- waste water which may be discharged only after reduction and pretreatment

and

- waste water which must not be discharged.

Standards for waste water discharge are either specified directly or must be derived from general, industry-specific or locality-specific requirements.

6. Mining/Raw-material recovery

Types of waste water occurring in this sector include polluted mine water and waste water produced during extraction or recovery of raw materials (further processing falls under manufacturing industry). The harmful nature of such waste water generally stems from high

concentrations of individual substances (e.g. arsenic, lead, zinc, mercury).

3.2 Waste heat

Waste heat is generally introduced into surface waters through the discharge of cooling water and heated process water by industrial plants and power stations.

The discharge of waste heat can interfere with the natural thermal condition of bodies of water, thereby adversely affecting water quality and living conditions for aquatic fauna and flora. The consequences of a rise in temperature in the vicinity of the discharge point include:

- **a decrease in oxygen content (on account of the reduced solubility of oxygen at high temperatures and a rise in oxygen demand resulting from the organisms' increased metabolism)**

- **adverse effects on individual organisms and changes in the spectrum of species**

- **reduction of the surface water's pollution load capacity and jeopardisation of its self-purification.**

Standards for discharge of waste heat into surface waters are generally not legally binding. As in Germany, however, they may be used as a basis for licensing procedures.

Relevant plant-specific standards for waste-heat discharge include the following:

- limits on the temperature of the water to be discharged (in C)

- limits in respect of the maximum temperature rise, evaporation losses and the maximum quantity of dissolved oxygen

- limits on the temperature of the surface water

The last-mentioned limits are immission standards, or ambient quality standards (see Section 4). The permissible temperature rise for a body of water indicates whether additional waste-heat discharges into the receiving water are permitted. Parameters relating to waste heat are generally set out in water-related guidelines (see register of EC environment treaties).

In order to assess the adverse effects on a body of water resulting from the discharge of heat, a whole series of data must be recorded and correlated with regard to application of the emission standards:

- volume and temperature of the cooling water discharged

- natural temperature and existing temperature of the surface water. A guideline can be provided by the average maximum temperature over a period of several years or the most unfavourable annual value ("summer value") on the basis of local flow and

weather conditions

- flow rate during the annual cycle

- BOD and COD

- presence of aquatic fauna and flora; biotope function

By means of calculations it is possible to produce temperature forecasts for a receiving water covering various flow rates, times of year, weather conditions and heat discharges and thus determine the thermal loading capacity of a receiving water as a whole or certain sections of it ("thermal load plan"). Calculating the temperature profile in this way is a complicated procedure. No standards specific to project activities are in existence.

3.3 Emission of gases and dusts

3.3.1 General

Gaseous and dust emissions are generated, directly or indirectly, by almost every form of human activity. Distinctions must be made between the following categories:

- concentrated emissions
- diffuse emissions
- drifting
- emissions occurring as a result of accidents

Depending on the nature of the materials processed, the techniques used and the extent of the emission control measures, industrial projects can give rise to emissions on a considerable scale. Emissions affecting employees at the workplace must also be taken into account.

In the agricultural sector, gaseous or dust emissions may result from use of fertilisers or tillage of the soil. Infrastructure facilities give rise to considerable emissions both during the construction phase and in the course of their use. The emissions generated by mining and raw-material projects generally take the form of dust; they may occur during open-cast mining, during handling of intermediate products or as a result of drifting from heaps. Finally, it should be remembered that households and small enterprises often constitute the principal source of emissions.

Existing emission standards are generally not based on the demands of nature conservation and environmental protection. Instead, they are determined by technical feasibility (recognised engineering practice, state-of-the-art) and by the extent to which they can be enforced in the sector or plant in question (economic position); they must thus be viewed as political and technical compromises.

Measurement of emissions is a complex process in which numerous marginal conditions play a role. The principal difficulty lies in the fact that most emissions are of a diffuse nature and may result from use of non-enclosed equipment in production facilities, drifting from heaps and the like. Measurement is easier in cases where emissions are concentrated through the use of covers, extraction systems or flues, e.g. encapsulated aluminium production facilities and furnace flues. As emissions are of widely varying types, the complexity of the process involved in measuring them increases in proportion to the number of pollutants to be covered. The current operating condition of a plant and the ambient conditions (temperature, wind) must always be taken into account when measuring emissions.

The measuring techniques themselves are complex and are continuously undergoing further development. Sampling conditions and certain disturbance factors have a considerable influence on results. The measuring techniques and procedural requirements for recording gaseous and dust emissions are described by a variety of sources. Details of the measuring specifications and the equipment to be used are contained in individual directives (Germany's Technical Instructions on Air Quality Control, *TA-Luft* EC directives etc.). Compilations of internationally used methods may be found in WHO publications (1990).

The link between emission and immission is formed by the dispersion calculation, which permits quantitative determination/forecasting of the likely immission on the basis of the causal relationship between emission and immission/deposition using models representing this relationship. There are various ways of elaborating a dispersion calculation, each of which

is based on different mathematical models. The following marginal conditions are among those which must be taken into account and included in the model:

- **physical distribution of sources**
- **changes in emission rates and emission composition over time**
- **dispersion conditions and changes in these over time and area**
- **physico-chemical processes in the atmosphere**
- **deposition effects (particle size, precipitation)**

Regulations laying down details of emission/immission measuring programmes, along with the equipment and analysis methods to be used, must fulfil demanding requirements, which may include recommending suitable equipment. Continuous emission monitoring is stipulated for certain types of plants. Additional requirements are imposed in certain cases, particularly with regard to measuring specifications for measurements performed in connection with licensing procedures.

Gaseous and dust emissions are known to have environmental impacts and increasing efforts are therefore being made to reduce them. The first step involves formulating guidelines which lay down emission standards for what are known to be the principal emission sources.

A specific deadline is generally laid down for achieving compliance with these guidelines. After this date the monitoring authority may take coercive measures in order to ensure compliance.

The industries concerned can comply with such guidelines by modifying the processes which they use or by implementing emission control measures. The manufacturers of emission-control equipment gear their products to existing technical conditions and statutory requirements and can generally offer appropriate solutions.

The development of emission control technologies is in a permanent state of flux and is continuously being brought into line with new findings. Emission control measures are combined with material and energy recovery wherever this is technically feasible and desirable. Emission standards relate in most cases to individual substances or groups of substances emanating from individual plants or sites.

Emission standards are given as mass limits in waste gas [mg/m^3], as pollutant output per unit of time ([kg/h] or [g/h]) or in the form of emission factors referenced to the mass of the products manufactured or processed ([kg/t] or [g/t]). Waste gases must not be diluted by adding additional air in order to achieve compliance with standards. In some cases, emission standards may be given in the form of a mass concentration graduated according to the mass flow of the substance in question (e.g. 75 mg/m^3 at 3 kg/h or more).

Geoecological conditions are not taken into account when emission standards are determined; instead, the figures are based on what is possible given current production and emission control technologies (recognised engineering practice). Only when future standards are being specified are possible improvements in processes taken into consideration. Some

countries take account of geoecological and meteorological conditions, as well as pre-existing pollution levels, by designating specific areas in which, for example, tougher standards are to apply under certain conditions. In most countries the standards for new plants are more stringent than those for existing ones (with no transitional provisions).

The introduction of emission standards also has economic impacts in that it may affect the operating results of an entire industry or give rise to a completely new market for emission control technology. When standards are laid down, attention is usually paid to ensuring that they are reasonable from the business-economics viewpoint (for the industry as a whole rather than in microeconomic terms). Countries which lack effective monitoring agencies may introduce standards "just for show" or take over unsuitable emission standards from other countries. The cumulative effect of emissions and the geoecological conditions are taken into consideration in determining ambient air quality standards or immission limits (see same) and compliance with them.

3.3.2 Project activities

Agriculture gives rise to atmospheric emissions through mechanical tillage of the soil (dust) and application of fertilisers, pesticides or animal faeces (ammonia).

Methane is produced by cattle and by swamp-rice fields, while activities such as burning of vegetation give rise to nitrous oxide emissions. For reasons of plant physiology, application of fertilisers and animal faeces is restricted to specific times; the same applies to use of

pesticides, which can likewise lead to gaseous and particulate emissions.

Although all such measures are the subject of recommendations concerning their execution and the quantities to be used, no restrictions in the form of emission standards exist.

In some countries, other measures such as burning-off of fields or banks are restricted to specific times or banned altogether, both in order to prevent emissions and to protect small fauna in particular.

Intensive livestock husbandry is particularly likely to give rise to emissions (especially odour nuisances). There are no standards limiting such emissions; instead, animals are required to be kept at least a stipulated minimum distance away from neighbouring properties. Liquid manure can be stored in closed containers or pits, while solid manure is usually left in the open.

The emissions generated by agriculture are in most cases mixtures of different substances which are extremely difficult to measure.

1. Transport (road, rail, water, air)

In considering the emissions produced by transport systems, a distinction must be made between the construction phase and the operating phase.

Gaseous and dust emissions are likely to be produced on a large scale during the construction phase on account of the use of heavy construction machinery and vehicles and the necessary earth-moving operations. On large construction sites, haul-away operations and storage of the required materials also give rise to emissions. There are no emission standards covering activities in this area.

Standards relate to the actual means of transport (vehicle, aircraft etc.) and compliance with them may be a requirement for operation under certain conditions (e.g. authorisation to operate vehicles in smog conditions, smog regulations).

Vehicle-specific standards are a subject of permanent debate in industrialised nations (manufacturing countries), where a wide variety of organisations endeavour to influence the establishment of standards and dates for their introduction (e.g. vehicle manufacturers, oil industry, environmental protection associations, governments). The outcome is ultimately a compromise between what is feasible in technical terms and what is reasonable from the economic viewpoint. In industrialised countries, compliance with emission standards for road vehicles is often monitored by means of regular vehicle checks. The measuring procedures developed for this purpose have been standardised, in some cases on an international basis, and are relatively quick and easy to perform.

2. Municipal waste disposal

Gaseous and dust emissions may be produced during disposal of solid wastes or waste water,

particularly where large quantities of solid waste are involved. Both domestic and industrial wastes can play a part in generating emissions. The principal sources of emissions are sanitary landfills, refuse incineration plants, composting plants and sewage treatment plants.

Where an organised waste disposal system exists, solid wastes are generally deposited on landfill sites or incinerated, in some cases with use being made of the heat generated during the process. Landfill sites can give rise to problems on account of unpleasant odours, production of sanitary landfill gas and scattering of waste material by the wind. Systems for the collection, treatment, and disposal of waste water may also create odour problems, particularly where the chemical and biological treatment stages are concerned.

In industrialised countries, only refuse incineration plants are required to comply with specific standards regarding gaseous and dust emissions. These standards are based on the extremely heterogeneous composition of the refuse and on the related pollutants to be found in the flue gas. The range of standards is being continuously expanded in line with detection possibilities and scientific findings on the effects of individual substances or substance groups. It is also possible that the thermal conversion process itself may produce new substances. The standards specified are geared to the possibilities offered by emission control technology, which is continuously undergoing further development. Other efforts focus on keeping certain substances out of sanitary landfills or incineration plants altogether.

3. Energy supply

Energy supply facilities are power stations which convert solid, liquid, or gaseous fuels into heat and/or electricity. The make-up of their emissions depends to a very large extent on the nature and composition of the fuels used. Apart from the main products of combustion, namely CO_2 and H_2O, the air may be polluted by CO, SO_2, NO, NO_2, heavy metals and incompletely converted hydrocarbons. Use of solid and liquid fuels will additionally give rise to emissions of fine dust, consisting of soot, SO_2 compounds and halogen compounds. As well as the type of fuel used, a plant's design and mode of operation also have a major influence on the nature and quantity of the emissions which it produces. Emission standards are therefore specified according to plant service condition and capacity.

The actual limit values stipulated are based on the pollutant content of the fuels and on the level of technical development attained in furnace and emission-control technology. Emission standards may also be graduated according to power stations' thermal capacity. Emissions can be reduced by means of fuel-related measures such as use of low-pollution fuels or fuel preparation. Other possibilities include optimising plant management and realising measures to reduce emissions in the flue-gas flow. Foremost among such emission-reduction measures are those involving dust separation, flue-gas desulphurisation and nitrogen removal. The substances covered by Germany's Technical Instructions on Air Quality Control ("TA-Luft") can be regarded as the most important where standards are concerned (see Register of Substances).

4. Manufacturing industry

Industrial operations cover an extremely wide range of fields. The volume and composition of gaseous and dust emissions are thus dependent on the process technology, raw materials and auxiliary materials used.

The emission standards introduced in a variety of countries relate in particular to SO_2, NO_x, constituents containing dust and components containing acid. The limits for dust emissions pertain above all to dusts containing heavy and non-ferrous metals. Emission standards have also been laid down for a variety of substances which constitute a health hazard or an odour nuisance.

Emissions are produced primarily during open mechanical processing operations and chemical/thermal conversion processes. The standards are based on the state-of-the-art with respect to processing, production and emission control technologies (in Germany standards of the German Association of Engineers *VDI* and DIN standards are used). It is a well-known fact that in some countries there is a considerable discrepancy between the standards laid down and the actual emission situation. The substances covered by Germany's Technical Instructions on Air Quality Control ("TA-Luft") can also be regarded as the most important where industrial emissions are concerned (see Register of Substances).

5. Mining/Raw-material recovery

Gaseous and dust emissions likely to affect the environment are produced during the

following operations:

- extraction (dusts, release of gases)
- transportation
- dressing, further processing, preprocessing
- stockpiling, storage (drifting, gas emissions)

For the most part, there are no standards relating to the primary operations involved in mining and raw-material recovery; regulations in this sector are concerned primarily with safety. Such standards as do exist relate to emissions produced during further processing, transportation and handling; they are based on the state-of-the-art as regards dust collection and enclosure technology, as well as on the concentration in the raw gas. Important qualitative standards include general requirements intended, for example, to restrict drifting during transportation and stockpiling, as well as grassing/recultivation measures.

3.4 Solid wastes

Solid wastes can be classed both under "chemical substances and substance groups" and - to a large extent - under "non-specific substance categories", which cover substances, substance groups, products, active ingredients, waste materials or general "waste" that cannot be clearly defined. Germany's Technical Instructions on Waste Management ("TA-Abfall") of 10 April 1990 contains information on the disposal of over 300 types of wastes requiring special monitoring. Particular attention must be drawn to the international agreements on the

dumping and transportation of solid wastes. An analysis of existing standards reveals that no quantitative standards covering the "production" of solid waste exist for any type of project activity (primarily agriculture, municipal waste disposal, energy supply, manufacturing industry, mining/raw-material recovery). Efforts are made instead to reduce quantities of solid waste by means of specific waste management measures such as mandatory recycling, deposit systems, obligations requiring manufacturers to take back products at the end of their useful life and so on. Extensive monitoring of production, storage, use, transportation and dumping is intended to preclude the possibility of health risks or adverse impacts on the environment, particularly where hazardous wastes or waste materials are involved.

With regard to project activities, particular note should be taken of regulations or recommended values applying to the following areas:

a) Agriculture

- **storage of solid and liquid manure**
- **disposal of solid wastes from large-scale livestock farming operations**
- **spreading of sewage sludges on agricultural land**
- **spreading of solid and liquid manure on the ground**

b) Municipal waste disposal

- **frequency and form of disposal, mandatory disposal (local by-laws)**

- procedural regulations (sanitary-landfill guidelines)
- mandatory recycling
- separate disposal systems for various types of refuse

c) Manufacturing industry

- obligation to record specific types of solid waste and solid wastes originating from specific plants (in Germany: the Waste Avoidance and Waste Management Act [Abfallgesetz] and administrative provisions)

- Various types of mandatory recycling

3.5 Chemical aids

The term "chemical aids" refers to chemicals such as pesticides, fertilisers, growth regulators, thawing salts and the like which are introduced into the environment for a specific purpose. They are used above all in agriculture and forestry to improve or modify growing conditions and to control pests, as well as in the transport sector to remove vegetation from roadsides and railway tracks.

Chemical plant protection uses effective substances in order, for example, to eliminate crop pests and thereby ensure optimum growing conditions for the crops. However, use of such substances for purposes other than those covered by their designated field of application can

result in adverse effects on groundwater, surface water, fauna, flora and soil quality. A particularly significant role is played by the high persistence of many substances in soil and water and by unknown toxic effects resulting from additive and synergistic processes.

Pesticides, fertilisers and growth regulators are covered by quantitative standards in the form of recommendations and regulations concerning

- **field of application (crop, pest)**
- **form of application (granules, emulsion, powder)**
- **time of application (e.g. as from a specific economic threshold)**
- **waiting periods (before harvesting or consumption).**

Restrictions covering the above-mentioned aspects are laid down by the manufacturers at the direction of high-level authorities (e.g. Biologische Bundesanstalt [Federal Biological Research Centre for Agriculture and Forestry] in the Federal Republic of Germany, Health and Welfare Secretariat in Mexico) and are generally substance-specific (see Register of Substances).

Recommendations on use of fertilisers are influenced primarily by yield-determining factors. They are not generally geared to geoecological conditions, although certain attempts are made to take such conditions into account. Under tropical climatic conditions, for example, even large-scale use of such substances is accompanied by limiting factors which automatically restrict agricultural production to a level well below that possible in comparable crop-growing regions in temperate latitudes and the subtropics.

Recommendations on pesticide use and the waiting periods to be observed following application are based on toxicological considerations relating to the maximum residue levels permitted by law. However, the relevant ordinances apply only to foods of plant origin and not to animal fodder. Sometimes irreparable damage can be caused by the hitherto unconsidered combined effects of numerous substances which can be re-assessed only gradually.

The extent to which it is possible to enforce regulations on the use of chemicals is limited by a number of factors:

- **language problems**
- **financial aspects**
- **acceptance problems**
- **training problems**
- **opportunities for monitoring**

The FAO Code of Conduct (one example of standards governing conduct in this field) is intended to improve the situation.

3.6 Changes in land-use

3.6.1 General

The term "changes in land-use" refers here to the process of

- making land-use more intensive
- making land-use more extensive
- or changing the form of land-use

and to the related changes in surface cover.

Changes in the intensity of land-use are most likely to be realised in the agricultural and forestry sectors, with the aim of increasing the amount of land used for production purposes or raising production on existing agricultural and forestry land. Other measures sometimes taken in connection with changes in the intensity of land-use, e.g. use of pesticides and fertilisers, irrigation and drainage, are discussed in the pertinent sections.

Changes in vegetation cover may have negative effects on

- soil usability
(e.g. erosion, compaction, nutrient leaching)

- availability of agricultural and forestry land
(e.g. reduction in size of forest stand, steppe formation, increase in waste land,

desertification)

- living conditions for flora and fauna
(e.g. alteration and destruction of biotopes)

- climatic conditions
(e.g. change in wind velocity and pollution rate)

- water resources
(e.g. change in groundwater recharge rate and run-off conditions)

Standards for measures affecting vegetation and changes in the intensity of land-use could take the form of mandatory requirements or bans in respect of particular types of land-use, or recommendations/guidelines for site-specific and region-specific forms of land-use management which are not merely geared to short-term economic interests but are also designed to preserve and enhance

- the long-term usability of key economic resources (particularly soil and drinking-water supplies)

- the ecological functions of the land (particularly with regard to climate, water balance, fauna and flora)

and to ensure the resultant optimum or desirable combination of land-use forms in a particular region (land-use structure).

Mandatory requirements and bans covering land-use include "standards" such as the following:

- Designation of areas performing protective functions
(water protection areas, nature reserves, closed forests etc.) in which specific forms of use or changes in land-use are not permitted

- Land-use management obligations
(e.g. adherence to specific construction methods, continuation of arable farming)

- Regulations limiting forest clearance
(only a specific proportion of the forest area may be cleared; such regulations exist in countries such as Uruguay and Brazil)

- Official authorisation necessary to transform forest into arable land/grassland or vice versa
(e.g. in some Laender of the Federal Republic of Germany)

Common to all these land-use requirements and bans is the fact that they are largely dependent on local and regional geoecological conditions and thus generally cannot be simply

taken over in other regions or countries. This does not apply, however, to the methods, ecological considerations and planning principles on which they are based.

Other changes in land-use stem above all from construction schemes (settlements, infrastructure facilities, industrial plants etc.) or specific functions (protected areas, rights of use etc.).

3.6.2 Project activities

1. Agriculture

For the purpose of raising production (particularly in regions with moderate to low yields), the intensity of land-use in agriculture may be changed by

- **enlarging cropping areas**
- **transforming forest and grassland/bush into arable land**
- **making the existing form of land-use more intensive/extensive**
- **livestock husbandry.**

In order to lay down standards for changes in the intensity of land-use and for the ecologically and economically optimum form of farming, regulations and recommendations geared to local and regional geoecological and economic conditions could be elaborated for the areas to be used. The farming recommendations drawn up by many national and regional agricultural

authorities are generally oriented to economic interests and can thus be drawn upon to only a limited extent for the purpose of environmental studies. In some cases, however, ecological considerations have now begun to feature in land-use management (particularly in certain pilot projects).

2. Forestry

Changes in land-use occurring in the forestry sector comprise the following:

- **Deforestation, clear cutting**
- **Afforestation**
- **Intensification of forest management systems**
- **Introduction of trees etc. not native to the site**

Standards can take the form of recommendations and guidelines for site-specific forest management, e.g.

- **clearance permits (to be made contingent upon afforestation measures)**
- **felling quotas**
- **specified rotation periods**
- **recommendations on selection of suitable tree species etc.**

3. Other project-specific aspects

A role is also played by changes in the basic purpose for which land is used and the related changes in - or removal of - the vegetation cover; in the broader sense, this also includes changes in function. Such developments are usually the result of construction schemes or administrative measures (e.g. designation of protected areas or special areas).

Depending on their nature and scope, construction measures and other changes in land-use can significantly impair environmental quality in that they may affect water resources, microclimate, biotope conditions and availability of agricultural and forestry land.

3.7 Removal of soil

Removal of soil comprises the excavation and displacement of soil necessitated by all types of construction measures. Large-scale removal of soil occurs in particular during extraction of raw materials near the surface by means of open-cast mining (gravel, coal, bauxite etc.) and construction of roads. Erosion is not treated here, as it must be regarded as an impact (see Section 5).

As a rule, neither removal and displacement of soil during open-cast mining nor filling work (e.g. in connection with road construction) takes any account of the soil's suitability for use or the function which it performs in respect of plants and the local water balance.

Virtually no soil-specific standards exist, as in most countries there is no executive agency responsible for the soil in its function as a scarce resource that can be easily destroyed. If the

aspect of "soil conservation" features at all, it is usually covered by regulations on land-use (see preceding section). Worthy of special note are a number of regulations and guidelines which aim to protect the topsoil (humus) against construction measures and the like.

A Soil Protection Act *(Bodenschutzgesetz)* is currently in preparation in Germany. It is to form the basis for Technical Instructions on Soil Protection (*TA-Boden*), which will lay down binding soil standards; the emphasis will be on precautionary measures and provisions for averting risks.

Contents - Previous - Next

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

3.8 Action influencing the water balance

Action influencing the water balance refers to activities which influence the quantity, physical distribution and time-related distribution of rainwater by means of construction measures. Virtually every form of economic activity involves action of this type, which includes in particular

- irrigation and drainage measures

- removal of water from, and discharge of water into, surface waters and groundwater

- changes in the flow conditions in surface waters as a result of development or correction measures etc.

- creation of surface waters such as impounding reservoirs, fishing waters, canals etc.

Depending on geoecological conditions and regional land-use, alterations to the available water supply by means of such measures can have impacts on

- the climatic situation (air temperature, humidity, air movement)

- the quality of the groundwater and surface water (dilution/breakdown/accumulation of pollutants)

- the soil quality and the availability of agricultural and forestry land (groundwater level, soil degradation)

- the living conditions for terrestrial and aquatic fauna and flora and thus also for pathogens.

Standards for allowed, permissible or environmentally sound forms of action influencing the water balance exist only as general guidelines for quantitative water management (e.g. Federal Water Act (Wasserhaushaltsgesetz) and Federal Nature Conservation Act (*Bundesnaturschutzgesetz*) in Germany). They can also be readily derived in this form from the general goals of environmental policy and have been formulated by bodies such as the FAO

and in certain environment treaties. It is stipulated that water resources are to be used in such a way that

- their long-term availability is guaranteed (i.e. they are not subjected to ruthless exploitation) and
- other functions performed by the natural household (see above) are not affected more than is necessary.

Precisely what this means for a specific project in a specific geoecological context can be determined only on a case-to-case basis, with particular consideration of the following aspects:

- precipitation (= primary water supply)

- the factors influencing how the precipitation divides up into evapotranspiration, surface run-off and groundwater afflux (particularly climate, vegetation, soil and geohydrological conditions)

- the requirements to be fulfilled by water resources

The granting of permits for measures requiring approval under water-resources legislation is intended to ensure that the goals referred to above are achieved (although it generally fails to do so). Particular attention must be drawn here to regulations laying down increasingly

ecologically-oriented requirements for hydraulic engineering measures and to special (research) projects which aim to promote ecologically oriented hydraulic engineering or related water-resource management.

Standards could conceivably be established for the following:

- **maximum permissible quantities of water that may be drawn off or introduced, where appropriate depending on the time of year**

- **acceptable changes in groundwater level (extreme values and periodic values) in the case of measures directly affecting the groundwater level**

- **flow rate of receiving waters (extreme values and periodic values) in the event of development measures**

- **flow velocity and turbulence**

With regard to project activities, particular note should be taken of regulations or recommended values applying to the following areas:

a) Agriculture

- **irrigation and drainage measures influencing the groundwater level/local**

water balance

b) Municipal and industrial water supply

- drawing of water from surface waters and groundwater
- discharge of polluted water and cooling water

c) Mining/raw-material recovery

- pumping out

d) Water development, which includes the following activities:

- creation of a body of standing water with a variable water level, in the upper reaches of a river (consequences: increase in water temperature, changes in chemism, water losses as a result of evaporation and seepage)

- creation of a more or less channelised stretch downstream of the impoundment (consequence: prevention of water exchange between groundwater and surface water)

- storage of water during the wet season and thus reduction of high water (and flooding) in the lower reaches and - due to delivery of water during dry

seasons - increases in flow (consequences in both cases: changes in water exchange between groundwater and surface water, delayed changes in water losses from evaporation)

- creation of irrigated areas (irrigation systems and large expanses of water) (consequences: loss of available surface water through seepage, evaporation and transpiration, but at the same time also recharging of groundwater through seepage)

- development of surface water to accelerate flow and to prevent high water and flooding (consequences: changes in flow rate, more pronounced high water downstream, lowering of groundwater level etc.)

3.9 Action influencing the surface configuration

Action influencing the surface configuration comprises measures which, extending beyond the soil bed, lead to morphological changes in the parent rock (C-horizon) or the lower-lying body of rock, as well as filling or deposition measures which significantly alter an area's natural topography (landscape). Unless industrial and domestic waste is being dumped, such measures always involve a process of redistribution, i.e. material is removed from one site by means of excavation near the surface or underground and then deposited elsewhere, generally by being placed or pumped as fill material. Only the utilisable raw materials are extracted for further processing or direct use (e.g. rock phosphate). Depositing of material

removed in this way does not necessarily have to lead to obvious changes in surface configuration. The practice of depositing material in the sea or in caves can also be of major ecological relevance but is not discussed in detail here since it is employed only in specific regions.

Depending on their nature and extent, measures influencing the surface configuration can have a wide variety of serious ecological impacts. They may influence the mesoclimate and microclimate, the available water supply and water quality, soil quality, availability of agricultural and forestry land, and biotope conditions. Extensive measures of this type are generally irreversible and have long-term ecological impacts. In such cases, recultivation measures do not restore the natural ecosystem, but rather create "substitute systems".

In ecological terms, the following are measurable criteria for surface configuration:

- **topographic height**
- **slope**
- **relief intensity**
- **degree of shaping**
- **exposure**

For measures below the surface, recourse can be had to the sole criterion used for technical reasons in other circumstances, namely:

- volume of the material excavated/moved.

Measures influencing the surface configuration have no direct effects from the human-ecology viewpoint (unless they involve the dumping of wastes) and give rise to no chemically induced changes in environmental quality. They are thus not covered by any relevant standards, since standards are generally based on toxicological aspects.

In terms of project activities, the following measures are of particular relevance here:

a) Transport

- **embankments, cuttings**
- **channels (shipping)**
- **technical facilities (bridges, tunnels etc.)**

b) Mining/raw-material recovery

- **open-cast mining (wet, dry)**
- **underground mining**
- **depositing of material removed**

c) Water development

- creation of ditch systems
- correction/development of rivers
- development of port facilities
- deepening of waters
- land reclamation measures
- construction of canals
- creation of impounding reservoirs

The ecological significance of such measures depends on

- the depth to which they extend
- the nature and composition of the rock beds exposed
- the size of the area covered
- the opportunities for recultivation (taking all natural environmental conditions together)
- the shortage of areas performing the same ecological function.

The impacts of such measures essentially comprise

- breaking-up of the habitat of flora and fauna
- impairment of the surface layer's effectiveness as a filter and thus hazarding of the groundwater
- climatic changes

- restricting effects on man's living environment and sources of subsistence.

Deposition of excavated material in the form of tips generally leads to major changes in surface configuration, whose ecological consequences depend on

- the height of the tip and the area which it covers
- the compactness of the tip
- the nature and chemical composition of the material
- recultivation measures (grassing etc.)
- erosion protection measures.

Approval procedures in most countries also lay down environmental protection requirements based on specific guidelines or regulations. There are no binding standards in the strict sense for action influencing the surface configuration (unless it directly involves other types of measures as well).

3.10 Noise emission

Noise is defined as the harmful environmental impact of sounds which, by virtue of their nature, volume or duration, are likely to give rise to health hazards or other adverse effects. The term "sound emission" refers to the radiation of sound from a sound source or a collection of sound sources (e.g. road, industrial area).

Sound emission does not lend itself to direct measurement. Instead, the noise level measured at a specified distance from the noise source or determined using a specified measuring set-up or calculation method is designated as the emission level. In the case of area-specific representations of immissions, the emission level is used as the basis for further calculation of the sound pressure at the place of immission (see Section 4).

For acoustic assessment of equipment, machines, vehicles or installations, the emission level is determined using a type-specific measuring procedure. This may be done, for example, in the course of licensing procedures in order to check compliance with specific emission standards.

Existing emission standards for technical sound levels are in all cases geared to the state-of-the-art; in other words, it is possible to comply with them for the purpose of any prototype or type approval procedures that may be necessary. They are determined on the basis of recognised engineering practice, taking the cost-benefit ratio into account. It is common practice for regulations first to lay down emission standards, graduated according to power and operating condition, which apply with immediate effect. Following consideration of technical, health-related and financial aspects, more stringent standards are then specified to take effect on a stipulated future date. The final step involves specifying machines which must fulfil tougher noise abatement requirements (see in particular the section on "International Environment Legislation"). There is virtually no monitoring of noise levels during day-to-day operation or use. As a result, actual noise emissions may exceed standards on account of

modification, wear or special uses of a machine or piece of equipment.

Contents - Previous - Next

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

---

4. Standards for environmental quality

4.1 Air quality

Depending on the emission conditions and meteorological factors, emission of pollutants into the air leads to atmospheric pollutant concentrations in excess of the natural basic level. The capacity of the atmosphere with regard to the distribution, breakdown and deposition of pollutants can be influenced by man only over small areas and even then only within relatively narrow limits (e.g. topoclimatic factors).

Immissions can be defined in terms of substance mass referenced to the volume of the contaminated air (e.g. mg/m^3). Standards in the form of volumetric concentrations are specified for gases in particular (e.g. cm^3/m^3). Standards for dust emissions are given in the form of particle concentrations (l/cm^3) or, in the case of deposition, mass per unit of area and time ($g/m^2 \times d$).

The Register of Substances (Section 5) contains immission-related information.

4.2 Climatic situation

Climatic changes may have a variety of anthropogenic causes, such as:

- **changes in surface cover**
- **irrigation and drainage measures**
- **action influencing the surface configuration**
- **creation of lakes**

Depending on the extent of such measures and local conditions, the resultant impacts may be either restricted to the specific area concerned (topoclimate) or of a global nature.

The key climate parameters comprise the following:

- **temperature and temperature profile**
- **humidity**
- **amount of precipitation**
- **frequency of fog**
- **strength and direction of wind**
- **intensity of radiation**

Such changes occur above all with regard to the topoclimate, with impacts on

- **agricultural production conditions (cold-air "lakes", balancing-out of temperature extremes by expanses of water etc.)**

- **soil erosion by wind (function of windbreaks)**

- **living conditions for fauna and flora, particularly for microorganisms and thus also for pathogens**

- **air quality (distribution of pollutants)**

- the population's health and well-being.

Whether a climatic change is rated as positive or negative depends totally on the situation in the case concerned and on the assessment criterion applied (which must be derived from the demands to be fulfilled by the individual environmental elements). Such an assessment will always be receptor-specific.

Although there are no relevant standards in the narrower sense, standards could be developed, at least in the form of desirable requirements to be fulfilled by climatic conditions, on the basis of the conditions leading to the impacts described above.

4.3 Noise situation

4.3.1 General

The noise situation is essentially described in the form of sound immission, which is taken as meaning the effect of sound on an area or on a point within an area.

The following factors are used to describe the noise situation:

- the magnitude of the continuous sound level (measured or calculated as an average

level over a specific period, e.g. for the daytime or night)
- the magnitude and number of peak levels
- the frequency of the noises
- the intervals elapsing between the occurrence of noises
- the nature and number of sound sources

Sound immission is generally measured in the form of the A-weighted sound pressure level, expressed in decibels (dB). The A-weighting is based on the sensitivity of the human ear.

To take account of the varying ratings attached to different noise sources, as well as for technical and legal reasons, area-specific ambient quality standards (immission standards) generally distinguish between individual installations or types of equipment and between the following categories of noise sources:

- industry
- traffic: road traffic, rail traffic, shipping, aircraft
- other facilities (e.g. leisure facilities, sports facilities, military installations etc.)

The effect of noise on human beings depends on the latter's physical condition and state of mind as well as the activity being performed (need for mental concentration, acoustic information and regeneration periods). It manifests itself in the form of demonstrable mental and physical reactions.

The extent to which particular sounds are regarded as constituting a noise nuisance is also determined by the social and cultural acceptance of specific sounds; to a certain degree, this acceptance is unrelated to the magnitude of the sound level.

In order to assess an existing noise situation or one which may result from a planning or construction measure, it is essential to determine the sound immission.

To this end, measuring and calculation procedures have been developed (e.g. in the Federal Republic of Germany: RLS 90, DIN 18005, Schall 03, 04) which make it possible to calculate average sound levels at a specific distance from a traffic route or the edge of a particular area on the basis of specific data on the size of the area concerned, type of industry involved, volume and composition of traffic, intervals between trains, speed, route characteristics etc.

To ensure that local residents are not subjected to aircraft noise on an excessive scale and to guarantee the implementation of appropriate noise abatement measures, noise abatement zones for airfields and airports are designated in Germany on the basis of the Aircraft Noise Act *Fluglrmgesetz*. These zones encompass areas in which calculations based on the number of take-offs and landings, composition of air traffic and runway location indicate that specific sound levels (equivalent continuous sound level) are exceeded.

Immission standards either have general validity or apply to specific categories of area for which - depending on their sensitivity to noise - differing levels are specified. In the Federal Republic of Germany the area categories given in the ordinance concerning the use of land for

construction purposes (Baunutzungsverordnung) are taken as the basis; it is assumed that a specific level of noise immission can be regarded as reasonable for each type of area.

The values laid down in guidelines and regulations were determined on the basis of empirically established links between sound level and noise nuisance, as well as the feasibility of enforcing them in local-authority development planning and transport planning.

4.3.2 Receptor-specific aspects

1. Human health

The effects of noise on human beings take the following forms:

- **damage to hearing**
- **hindering of acoustic communication**
- **activation of the central and vegetative nervous systems**
- **impairment of performance**
- **nuisances**

However, the extent of a noise nuisance is determined not just by the noise level but also by a variety of other factors (see above). In general, it can be said that average levels of 55 dB(A) at night and 65 dB(A) during the daytime represent the limits of acceptability. Noise levels in residential areas should not exceed the guide values specified in the German DIN standard

18005, namely 40 dB(A) at night and 50 dB(A) during the daytime. Sleep disturbances on account of noise are unlikely where the average level is below 35 dB(A) (recommended value for residential areas in respect of industrial noise, as laid down in Germany's Technical Instructions on Noise Abatement *TA-Lrm*: 35 dB(A)). Hearing is likely to be impaired when the noise level at permanently occupied workplaces is 85 dB(A) or more. Standards are laid down on the basis of nuisance or damage characteristics that can be readily objectivised, taking into account what is feasible and affordable from the planning viewpoint.

2. Conservation of fauna and flora

Noise essentially affects fauna in the following ways:

- **Continuous noise disrupts acoustic communication and thus leads to changes in behaviour as regards mating, food gathering, warning signals and brood care, resulting in changes in natural biocoenoses in the area near the emission source.**

- **Individual noises, which may sometimes occur in conjunction with visual signals, can give rise to panic reactions, which at certain times - for example during territory-seeking or brood care - may result in habitats being permanently abandoned and reproduction endangered.**

The following factors can be considered in assessing the impacts of noise immissions:

- species
- previous noise stresses (adaptation)
- type of noise (regularly recurring, sporadic etc.)
- visible changes in behaviour
- proximity of noise source to habitat

4.4 Available water supply

4.4.1 General

The usable supply of groundwater and surface water is defined as that proportion of the water suitable for a particular purpose which can be used in an economically efficient manner, which is available on average over a lengthy period and whose withdrawal is ecologically acceptable.

If the quantity of water taken from water resources exceeds the usable supply, vegetation will die off and streams and springs will run dry. The existence of opposing interests is likely to give rise to conflicts. The volume of groundwater that can be withdrawn is restricted on the one hand by the long-term need to ensure supplies of drinking water and process water and on the other hand by the demands of vegetation and agriculture.

The natural groundwater recharge rate (volume of water added to groundwater per unit of time and area) depends on geoecological conditions such as

- **geological situation (above all permeability of surface layers, groundwater reservoirs)**
- **distribution of precipitation**
- **soil conditions**
- **vegetation**
- **other climatic factors**

and on influences of anthropogenic origin, such as

- **building (sealing of land)**
- **exposure of groundwater surfaces (e.g. as a result of gravel extraction)**
- **drainage measures (e.g. wells, channels, creation of large artificial lakes)**
- **soil compaction (e.g. caused by livestock, machinery, drainage)**
- **changes in vegetation.**

Use of land for construction purposes plays an important role as regards the efficiency of the natural household, as the equilibrium between the individual components of the water balance is disturbed if open areas are increasingly sealed. Seepage is reduced; water accumulates in the body of receiving water (high water) and may cause evaporation to increase. The same happens if the soil is compacted as a result of construction measures or

inappropriate tillage.

The withdrawal of large quantities of water adversely affects the living conditions of aquatic organisms, since it means that flow is reduced and the water temperature consequently rises. Changes in periodic flow rates as a result of impounding measures will adversely affect or destroy appropriate life forms and lower the groundwater level.

4.4.2 Receptor-specific aspects

1. Human health

The most important consideration is the need to meet man's quantitative requirements in respect of water for drinking and other purposes. Requirements depend on standard of living, consumption habits and water availability, which means that consumption levels vary widely.

It is relatively easy to determine per-capita drinking-water requirements (in litres). By contrast, the extent to which the available supply of water suitable for drinking has actually been ascertained varies greatly from one country to another. Renewal of resources is the subject of more or less valid estimates; it is often uncertain whether supplies can be replenished with water of equal quality.

Standards should always be based on the number of people involved, consideration of population trends and the fact that the water replenishing the supply does not necessarily

have to fulfil the qualitative requirements. Ensuring of drinking-water supplies should be given priority over other forms of water use.

2. Natural household

Changes in the available water supply can influence the efficiency of the natural household. The function of the receiving water as part of a cohesive drainage system can be adversely affected by changes in flow. An increase in flow rate can lead to flooding, while a lower flow rate will reduce the removal of entrained substances.

The following negative impacts may occur:

- **damage to agricultural irrigation systems**
- **damage as a result of dryness, harvest losses**
- **varying degrees of soil subsidence (changes in soil water balance)**
- **disruption of water supplies**

3. Conservation of fauna and flora

The availability of water plays an important role in the development and preservation of a specific plant community. Major interference with the water balance thus leads directly to changes in biocoenoses caused by

- changes in groundwater level, particularly lowering of the groundwater level
- changes in the water level and flow in surface waters.

Region-specific environmental standards must be based on the requirements of the biocoenoses and the various organisms which they contain, above all with regard to

- minimum depth of surface waters
- minimum groundwater level
- periodicity of the available water supply
- minimum water quantity.

4.5 Water quality

4.5.1 General

The natural quality of surface water and groundwater is influenced by the continuous introduction of substances and by continuously changing parameters. The introduction of substances into the water by man or nature is offset by self-purification processes, in which these substances are broken down by organisms which multiply in the water on a large scale. This functions only up to a specific system-dependent loading limit, above which the character

of a body of water may undergo fundamental changes.

The concept of water quality is defined by

- **the natural properties of a body of water or of the trophic level**
- **the water's current or potential use and the related quality requirements.**

Physical effects (e.g. temperature increases) and chemical action may have such a sustained adverse impact on water quality that the specified quality requirements can subsequently be met only with the aid of technical treatment measures.

The differing quality requirements for various types of water use necessitate a variety of specific standards, in particular:

- **standards for drinking water**
- **standards for water/bodies of water used for bathing**
- **standards for agricultural irrigation water**
- **standards for protecting aquatic organisms**
- **standards for industrial water supplies**
- **standards for livestock drinking water**

For general purposes, i.e. without reference to a specific form of use, the condition of a body of water can be defined by means of

- its quality classification
- its temperature status.

The quality classes can be used for determining immission standards by stipulating that the requirements of a specific quality class are to be fulfilled at national or international level (see the section on environment legislation).

Division of a body of water into quality classes relates primarily to its pollution with organic substances that are biodegradable under oxygen-depletion conditions.

The graduated differences in the biological condition of flowing waters, occurring in the course of the self-purification process, are described in the saprobic system, which gives characteristic organisms or combinations of organisms for the various quality classes. The system is based on the observation that the communities of organisms found in polluted waters, and the frequency of the organisms' occurrence, differ from those in unpolluted waters. Although the saprobic system was developed for central European flowing waters, its basic principles can also be applied to conditions in other regions (see also WHO guidelines, various years).

It is relatively simple to determine water quality with the aid of indicator organisms and easy-to-record chemical parameters such as temperature, pH value and oxygen content. However, laboratory techniques - some of them complex - must be employed to ascertain the presence of more specific substances such as hydrocarbons. The chemical data provide only a rough

idea of frequently occurring concentrations. Efforts are being made to achieve a realistic representation of the degree of water pollution with the aid of summation or collective parameters (BOD, COD). Use of these parameters simplifies matters, as it is virtually impossible to conduct a comprehensive analysis which covers the wide range of polluting compounds in its entirety. Some of the substances are treated in the section on chemical substances. Information on important EC directives on water quality, including the related parameters and standards, is contained in the section on EC environment legislation.

4.5.2 Receptor-specific aspects

1. Water quality/human health

Use of groundwater, spring water and surface water as drinking water and for purposes of personal hygiene is subject to specific quality requirements. The available raw water, particularly surface water, seldom fulfils these requirements. The substances naturally contained in the water, contamination caused by the activities of man and possible changes occurring during transportation mean that the water must be treated before it can be used.

Treatment of drinking water is intended on the one hand to preclude the possibility of health risks and on the other hand to ensure that the water meets certain sensory requirements, e.g. in terms of taste or odour.

The quality requirements to be fulfilled by bathing waters are intended to make sure that

recreational activities such as swimming, water sports, fishing etc. do not involve any health risks. Apart from aesthetic standards covering aspects such as odour, clarity and colour, such requirements also relate to parameters representing health hazards, particularly the water's bacterial constituents.

2. Conservation of fauna and flora

Changes in natural water quality also affect the organisms found in aquatic systems, e.g. bacteria, algae and water plants. Water pollution may influence the natural living conditions in a variety of ways, for example through

- **changes in oxygen content**
- **temperature changes**
- **changes in nutrient supply**
- **direct toxic effects.**

The behaviour, reproduction and physiology of organisms may all be affected. Resistance to specific pollutants will result in these substances being passed on in the food chain. Harmful effects may threaten individual organisms or particular species. There is also a possibility of combination effects where a variety of different substances are present.

3. Preservation of the efficiency of the natural household

Permanent or at least long-term use of the natural resource represented by water simultaneously gives rise to changes in the water. In its function as a factor of production or a resource for use by man, water must thus be safeguarded on a long-term basis. Quality requirements exist for agricultural irrigation water and for water to be used in various sectors of industry. Such requirements should not be regarded as environmental standards in the true sense, however, as they focus primarily on the technical usability of water as a raw material. They can nevertheless offer certain pointers regarding the relevance of specific constituents or parameters (see WHO guidelines, particularly those on environmental engineering; WHO, 1990 etc.).

4.6 Soil quality

The soil forms the weathering layer of the Earth's solid crust. Its characteristics and development depend on the prevailing geological, topographic, climatic, hydrological and biological conditions. The term "soil quality" is generally taken as referring to a soil's suitability as a location for plants in the sense of its productivity. A frequently used synonym is the term "soil fertility", which describes the soil's ability to supply plants with nutrients, water, oxygen and warmth.

Apart from providing the basis for food production, soil conditions create the essential prerequisites for all terrestrial production of phytomass and thus form the foundation of virtually every food chain.

In addition to performing this vital role in safeguarding the existence of higher life forms, soils fulfil an important function within an ecosystem as

- **filters and sinks for potential pollutants**
- **a habitat for soil flora and fauna**
- **the site of conversion and breakdown processes forming part of natural cycling systems.**

The major types of impact on the soil can be classified as follows according to their basic nature:

1. Chemical changes result from

- **application of fertilisers**
- **use of biocides and**
- **pollution caused by various immissions and depositions of anthropogenic origin (direct introduction of pollutants by wastes and waste materials, either solid (sanitary landfills, tips) or liquid (waste water, hydraulic fill); indirect introduction of pollutants following aerial transmission, through deposition of liquid or solid aerosols and introduction via precipitation).**

2. Physical changes result from

- removal of soil (removal of individual layers, excavation)
- changes in the natural vegetation cover (land clearance, use of land for forestry)
- tillage (use of land for agriculture, terracing etc.).

3. Biological changes result from

- use of biocides and
- introduction of potential pollutants.

Changes in the water balance generally have direct effects on the chemical, physical and biological conditions in the soil.

The principal soil parameters are as follows:

- **With regard to physical condition:**
  Structure, aggregate stability, pore volume and distribution, granulometric composition, density of mineral matter, density of organic matter and soil temperature

- **With regard to chemical condition:**
  Content and chemical composition of mineral and organic matter, acidity, ion exchange capacity, redox properties

- With regard to biological condition:
Nature, composition and size of the edaphon

Analytical determination of soil condition, particularly of chemical properties and the reaction mechanisms and processes controlled by them, may present considerable problems in some respects.

Apart from determining the chemical composition of soils as mentioned above, the following key parameters are generally used for establishing soil quality:

- granulometric composition
- organic-matter content
- pH value
- cation exchange capacity
- base saturation
- field capacity/available field capacity

It should be borne in mind that soils yielding identical individual values are not necessarily of identical quality. Soil classifications (which vary depending on purpose and viewpoint) must be drawn upon in determining standards which take account of the diversity of soils and their optimum condition in each case.

Standards relate to soil quality in terms of suitability for agricultural use (soil evaluation), to

erosion risks and to pollutant deposition. The Register of Substances contains more detailed information about substance-specific soil quality standards.

4.7 Agricultural and forestry land

Agricultural land provides the raw materials necessary to ensure a food supply. The amount of land needed per capita to meet staple-food requirements varies depending on geoecological conditions (particularly soil quality, available water supply and climate), eating habits and the level of development attained in agricultural engineering. The figure arrived at on the basis of a region's population and the above conditions can be taken as a standard for the amount of agricultural land required. In view of the influencing factors referred to above, standards of this type can be determined only on a region-specific basis.

Disregarding the ecological functions performed by forests, the minimum amount of forestry land required is determined by the population's requirements in terms of wood and other usable forest components (leisure, medicaments, plants/fruits etc.). It depends on geoecological conditions and local habits (e.g. fuel needs).

The availability of agricultural and forestry land is influenced in particular by

- changes in the purpose for which land is used (transforming forests into agricultural land, transforming agricultural and forestry land into areas for settlement, transport routes, industry, mining operations etc.);

- the damage done to the soil by pollutants, erosion, removal etc. as the direct or indirect consequence of other economic activities or minimally site-appropriate cultivation practised with a view to preserving the soil's usability in the long term.

In general, such standards for the minimum amount of agricultural land required take the form of empirical values applying to specific countries or regions. Depending on the conditions outlined above, the figure given may be many square kilometres (extensive pasture farming), roughly one square kilometre (shifting cultivation), one hectare (e.g. rice-growing) or less (horticulture). No corresponding figures are known to exist for forestry land.

4.8 Biotope conditions (special biotope functions)

This section covers biotope-related aspects not considered in connection with the environmental quality parameters previously discussed. In terms of composition and density, vegetation and fauna constitute a community (biocoenosis) which has developed over a lengthy period through the interaction of the relevant ecological factors and which occupies a more or less precisely defined habitat (biotope). An ecosystem consists of an indefinite number of biotopes exhibiting a specific form of interdependence.

The conditions to be met by an "intact" biotope are derived from the communities' requirements in terms of the environment necessary for the preservation of species. The major determining factors are

- biotope-specific minimum area
- interlinking of areas
- diversity of structure and species (to offset disturbing influences)
- absence of disturbances.

Scientific research has yielded findings on effect chains in ecosystems, the extent of changes caused by external influences and the biotope requirements of individual species (above all particular index species such as large fauna, birds and protected species) which make it possible to define area-specific "environmental standards". Every species (flora or fauna) forms part of a biotope, where it plays a (generally) indispensable role. If one element of a biotope is removed, both the composition and the functioning of the biotope will be changed or disrupted. Although there are no standards (in the strict sense) for biotope conditions that ensure preservation of fauna and flora, such standards can be formulated for specific regions on the basis of the characteristics of the region's typical biotopes. Certain attempts are being made to find a meaningful substitute by considering natural substance cycling systems and the energy cycle. Apart from the national protected status of specific areas, one pointer for determining the extent to which areas merit protection could be provided by information on the (potential) occurrence of protected species (e.g. species threatened with extinction). Particular attention must be drawn to the Washington Convention on International Trade in Endangered Species (see section on the international environment legislation) and Germany's Federal Ordinance on the Conservation of Species. However, the "red lists" are based only on the criteria of endangerment and rarity. Other criteria should also be taken into account, e.g.

benefits and importance for the natural household or the need to preserve the diversity and characteristic features of the natural environment and the landscape. Measures to protect biotopes must be concretised in line with specific regional needs following analysis of relevant conventions to obtain information on particular species.

4.9 Food quality

Alongside outward quality features such as weight and size (based on marketing strategies), general food quality criteria also include "internal" characteristics such as absence of pollutants, nutritional value and taste. In connection with environmental standards, food constituents can serve as yardsticks for the toxicological assessment or admissibility of pollutants and in particular of chemical aids in the environment. They thus have only an indirect bearing on the environmental impacts of specific projects. They can be used if necessary as a qualitative criterion in concrete environmental studies. Some of the existing standards are given in the information sheets forming part of the Register of Substances. Further information on food quality and the residue problem can be found in particular in the Ordinance on maximum quantities for pesticides and aflatoxins, the pesticide list (1990) compiled by the Biologische Bundesanstalt fr Land- und Forstwirtschaft [Federal Biological Research Centre for Agriculture and Forestry] and the WHO Food Additives Series (various years). The major factors influencing the pollutant content of foods are

- the substances/pollutants contained in soil and irrigation water, either as natural

constituents or introduced as a result of action by man

- the uptake of airborne pollutants
- the use of pesticides and fertilisers
- the use of drugs in animal production
- biogenic conversion products.

Pollutants in soil or on plants may have an indirect effect on man via the food chain. The accumulation processes that can occur in the food chain and the receptor-specific effect of substances mean that a food may contain extremely harmful pollutant concentrations without the growth of the original plant having been affected in any way.

Sometimes, however, pollutants can have adverse effects on plants' reproductive capacity and pest resistance.

The extent to which contamination of environmental compartments influences the pollutant content of foods depends on the individual crops' specific uptake rate in respect of the substances concerned (so-called "transfer factors"). Standards for environmental media generally do not take account of accumulation processes or synergistic and receptor-specific phenomena.

Contents - Previous - Next

5. Chemical substances and groups of substances/register of substances

5.1 General

Environment-oriented laws, directives and recommendations are generally drawn up on the basis of environmental media/sectors (e.g. EC Water Protection Directive, German Soil Conservation Concept, Technical Instructions on Air Quality Control, TA-Luft). The specifications are made by pertinent authorities or advisory institutes (such as Federal Health Authority, DVGW or IWAR) and generally relate to (sovereign) areas. Against the backdrop of different starting points (economic, geographical, ecological etc.) the laws enforced have a limited sphere of influence in terms of the area they cover. Given such prerequisites they cannot always be simply transferred to other ecological and/or political situations. To quote an example, the demands made on water quality in arid climates are completely different to

those imposed in Central Europe. On the other hand, the temperature stipulated for waste water introduced into a receiving stream will be far lower than in tropical or subtropical zones.

5.2 Explanatory notes on content of "register of substances"

The compendium section "Register of substances" takes the regulations (e.g. surface water) from various countries, which are usually referenced to utilisation (e.g. sector) and area, and breaks them down on a substance-specific basis with an indication of their origin and the individual stipulations affecting them for the purpose of comparison. This is done on levels with differing degrees of differentiation so that this section of the compendium can be of assistance with decision-making above all in situations where:

- there are no stipulations when planning individual utilisation,

- the ecological effect of a planning measure goes far beyond existing usage regulations and further assessment is therefore necessary,

- existing regulations are to be checked.

The information sheets in the register of substances not only contain official limit/guide values for the various chemical substances, but also a wealth of assessment criteria. The additional data in the information sheets were structured so as to avoid a detailed text section

with explanatory notes and to provide users with the necessary details in clear-cut form in the relevant places.

The diversity of data often made it necessary to evaluate a wide variety of literature sources with the accompanying research work likewise resulting in a whole range of pertinent, continuously updated sources such as loose-leaf binders and handbooks. These appear in bold print in the bibliography and source list. Following the analysis of suitable information media and data sources, evaluation was essentially based on the specialist catalogues/materials of the State Library in Berlin, the Library of the Federal Environment Agency in Berlin, the Library of the Technical University in Berlin and a wide range of faculty libraries at the university (environmental engineering, chemistry, geography, landscape ecology).

The information sheets encompass the following data blocks; details are outlined in the explanatory notes which precede the register of substances:

- basic chemicophysical data
- origin and use
- environmental standards
- comparison and reference values
- assessment/comments
- toxicity
- environmental behaviour

The data sources investigated provided a wealth of different information of differing quality. The project framework likewise lent itself to the establishment of focal points both in terms of substance selection and depth of investigation. The items dealt with/information sheets compiled are therefore in no way all intended to reflect the same level of detail.

5.3 Selection of substances

Generally speaking, all substances found in the environment - irrespective of whether they are natural or anthropogenic - are of importance to the ecosystem and thus of relevance to the environment. Numerous authors have endeavoured to compile and select environmentally relevant substances and - in line with their differing premises - have produced substance lists containing between approx. 100,000 (INFUCHS data bank; acc. WAGNER 1989) and 60 substances (BUA, 1989). The majority range however between several hundred and a few thousand entries. An interesting outline of the problems involved is given by the BUA (1989) together with a range of chemicals lists from other countries.

Within the framework of environmental impact assessments (EIA), all anthropogenically induced material changes to the natural environment and their effects are of potential interest. The number of substances involved is thus of such proportions that it will not be possible even in the long term to prepare them for practical EIA implementation. The CES reflects the following priorities in terms of substance selection.

1. Of the numerous compounds in existence, the substances selected were those which are

already covered by legal provisions. On the one hand, they represent the core zone by which EIAs must be guided on account of clear-cut specifications; on the other hand, it can be assumed that competent authorities have already classified these substances as being particularly hazardous to the environment since laws are not usually passed until the hazards emanating from a given substance have been scientifically proven.

Both the number of substances subject to legislation and the specified limit values differ greatly from country to country. Environmental legislation in the Federal Republic of Germany is relatively authoritative and progressive in international terms. Along with EC stipulations it represents the basis for the substance selection used here from the legislative sector. The corresponding general table in the substance register "environmentally relevant chemical substances" was based on:

- **list I of the Directive 76/464/EEC for the environment medium "water",**
- **the Soil Conservation Concept of the German Federal Government for the environment medium "soil" and**
- **the Technical Instructions on Air Quality Control TA-Luft for the environment medium "air".**

Assessment was made in line with a list compiled by WAGNER (1989). The regulations outlined above contain 171, 228, and 280 substances, respectively. Allowing for once-only listing of substances which appear in several regulations thus produces a total of 525 compounds.

2. The 525 substances covered by legislation were supplemented to include 6 other substances (atrazine, barium, carbaryl, hydrogen fluoride, methyl bromide, ozone) considered to be of environmental relevance with the result that the index contains a grand total of 531 substances. It is, however, not to be considered as final and will be extended. Thus, for example, there is no reference to important nutrients such as phosphates and nitrite. Furthermore, compilation of the information sheets revealed a small number of relevant substances which have not been covered to date. The ultimate scope will probably be between 560 and 570 substances.

Number of substances and substance groups arranged according to legal provisions and in-depth data sources

	Regulated or named substances		
Legal provisions/data sources	**Total**	**of which: listed in the table**	**of which: treated in information sheet (register of substances)**
1. EC Water Protection Directive List 1 (1982)	171	171	29
2. Catalogue of substances hazardous to water (1987)	approx. 600	180	33
3. Soil Conservation Concept	228	228	40

(1986/87)			
4. TA-Luft (1986)	280	280	35
5. MAK values (1989)	approx. 600	205	47
6. Environmentally relevant substances selected for CES (1990) which are not named in 1,3,4	6	6	6
Grand total		531 (single listing only)	62

TA-Luft: Technical Instructions on Air Quality Control as per Federal Immission Control Act

MAK values: Maximum workplace concentration (s.DFG, 1989)

Note: **The table *Chemical substances of environmental relevance arranged according to selected laws and guidelines* lists some substances which are not treated as a single substance in the *Register of substances* but which may be assigned to a group of substances whose information sheet exists in this register (e.g. acenaphthene is a member of the polycyclic aromatic hydrocarbons and heptachloro-dibenzo-p-dioxin belongs to the dioxins group). Thus, information on 140 substances from this table may be refound in the register. The page references of these substances are put in parentheses.**

Contents - Previous - Next