3. Notes on the analysis and evaluation of environmental impacts

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On the basis of the elements of environment-oriented transport planning considered above and the discussed environmental impacts of traffic and transport, together with the relevant protective measures, some notes are given below as to how these environmental impacts can be systematically analysed and assessed within the scope of transport planning.

3.1 Identification and analysis

According to [1], the **environmental impacts of transport systems caused by installations and traffic** are essentially **determined** by:

- the share in transport volume of the particular system,
- the actual total volume of transport,
- the type of energy used,
- the speed of transportation,
- the energy and emission values specific to the transport medium (pollutants and noise),
- compatibility with other transport systems in a common transport environment,

- the specific burden per unit of area caused by the transport installations and their supplementary equipment (such as tank farms, workshops etc.) through intersection and loss of land.

In so far as these underlying variables can be statistically identified, they may be combined into the following **affected areas**:

At the national level:

- total consumption of primary types of energy caused by transport,
- total emissions caused by transport (CO_2, air pollutants),
- total surface area used,
- accident figures,

For individual regions:

- area utilisation in comparison with the overall area,
- divisive effects on society, the economy and fauna,
- contamination of air, soil and water,
- accident black spots,
- noise black spots,
- endangerment of cultural heritage through vibration and exhaust gases.

3.2 Evaluation

These **nationwide and regional environmental impacts** of transport and traffic should be **compared** with

- the overall burdens, sensitivities and burden limits (where defined),
- the impairment of agriculture, leisure and recreation areas, and both rural and urban landscapes,
- positive effects of transport and traffic on the economy, social structure and town and country planning

From this, we can **infer** (largely in **qualitative terms**),

- what environmental impacts of transport and traffic contribute particularly heavily to the total or regional burden,
- what resources can be used to reduce these with optimum effect (i.e. with minimal impairment of the desired effects of transport); directly, through control of the overall transport and traffic plans and regulations on maintaining and expanding transport routes, and indirectly by way of levies and decrees),
- where points of conflict arise,
- where there is a need for coordination and cooperation with plans of other sectors,
- where there is a need for more in-depth research.

The comparatively **low levels of awareness** of the **effect on the ecosystem** in many countries (see 2.3) must **be taken into account** when imposing limits.

Past analyses and evaluations must be **continuously updated and scrutinised** in the interest of ongoing **improvement in the quality of forecasting**.

3.3 Participation by third parties

Besides data acquisition, it is also vital to **take account of region-specific, socio-cultural elements and socio-economic factors.** In order to identify and analyse these, is it **essential to secure the early cooperation of both directly and indirectly affected parties in the planning and decision-making processes, and to guarantee this by law. Participation** by these groups or by the state bodies directly involved in the region can, for example, be brought about by carrying out surveys among the local religious and secular leaders or by holding meetings and public hearings. It is often in this way that ecological systems and their **significance for the human population** of the regions become **known** for the first time; this also helps **avoid fatal misjudgements, unwitting destruction** of the systems on which life depends and violation of religious taboos (see also [7]).

In a similar way, **transport users, drivers and operators should likewise be involved.** This may bring to light the often **informal reasons** for travel, which confound the theory (for example, lorry drivers sometimes prefer routes through densely populated areas so that they can pick up loads and passengers for private remuneration; in these cases, bypass roads may be less popular). The **interests of all transport user groups** (including women and children, for example) need to be **analysed** and **incorporated into the overall planning** (e.g. transport of products to markets and road safety).

Representatives of the affected population groups may **cooperate in the monitoring process to ensure that the agreed plans and regulations are adhered to.**

4. Interaction with other sectors

Transport and traffic planning may act as a **link** and indeed as a **desirable or undesirable controlling variable** (driving force or bottleneck) for vertically and horizontally adjacent sectors involving physical transportation and the provision of energy, in particular:

I) **National and regional planning:**

The scope and density of a country's transport network are closely related to the national and regional planning objectives. **Centralised structures** with concentrated land-use call for a **more sophisticated system of distributing labour and goods** and therefore require **higher transport capacities.** By contrast, regional and national planning which focuses on small-scale operations and decentralisation will tend to reduce the transport demand. This must not entail any reduction in general living standards.

An **environment-oriented national (development) and regional planning programme** has, in particular, an important **cross-sectional function** for all regional planning activities of the individual sectors, including transport planning.

II) **Industrial planning:**

The **development of industry** calls for **quick and easy accessibility** and **trouble-free transfer of goods.** Deliberate relocation of established businesses must take account of the consequences with regard to transport and traffic.

III) **Agriculture and forestry:**

Agriculture and forestry impose **differing demands on transport routes and systems**, depending on the **intensity of land-use.** The particular **risks** of opening up forests to traffic and **relevant precautions** are discussed in 2.4.

IV) **Municipal and local planning:**

Municipal and local planning is indissolubly bound up with transport and traffic planning; Sections 1.2, 2.4 and 2.6 deal with the **new approach required in this context on the ecological and social levels.**

V) **Water management:**

Not only the **use and planning of shipping routes** have to be coordinated with water planning, but also the **effects of land transport routes on the water supply and water quality** (cuttings, embankments, pipelines, vehicle emissions, and safety measures in water conservation areas).

VI) **Training and education:**

The **importance** of **safeguarding the environment** and the **contribution made by transport and traffic planning** must be taught, particularly in **professional training** (e.g. in training courses for construction engineers, traffic and transport planners, urban and regional development planners), and as part of internal **advanced training** in administrative bodies. **Integrated courses** must be offered to show the interactions between different planning sectors. It is also important for the state to set the public an example, as discussed in 2.5. Moreover the **(opinion-forming) media** can also play a **significant role** in broadening environmental awareness.

Other sectors **affecting the geographical distribution of transport and traffic routes** and the **types of transport** are:

VII) **The energy sector:**

Decisions regarding the **transport medium** for transporting personnel and goods should be considered in the light of what is the most economically and environmentally favourable **energy source**. For example, countries with an **adequate supply of electrical power from**

regenerative sources (hydroelectric power) often fail to make the most of the potential for electrically-driven vehicles.

VIII) **Tourism:**

Tourism not only requires **"well-developed"** (but perhaps **ecologically doubtful**) **routes to tourist destinations**, but may also bring tourists to **previously unspoilt areas** and thereby **damage** them.

5. Summary assessment of environmental relevance

Environment-oriented transport and traffic planning should be based on the following **principles:**

1. **Transport and traffic** have a **direct effect** on people through **accidents and health hazards,**

on a regional level due to **interference with regional ecosystems**, and in particular due to **uncontrolled settlement and land-use** through areas being opened up to traffic and **on a global level** through the **burning of fossil fuels** and the **reduction in the diversity of species.**

2. The scope and nature of these environmental impacts depend on

- the volume of traffic,
- the mode of transport,
- the type of propulsion concerned,
- the type of fuel used,
- driving practices (speed and acceleration behaviour)
- and the design of the transport routes.

Transport and traffic planning can make a deliberate contribution towards **controlling these factors.**

3. The **volume of traffic** is first and foremost a **function of the distribution of labour;** this in turn closely **interacts** with **social and economic structures.** Changes to these will not necessarily cause a fall in living standards.

The **volume of traffic** can be **reduced** by **more rational use of vehicles**; **higher variable levies** seem to be particularly suitable as an incentive to achieving this.

4. If transport modes are not dictated by the structures referred to above (e.g. the need for markets to be served by heavy goods vehicles), the **use of environmentally and socially compatible transport modes** should be planned. This applies particularly to the **opening up of regions** in connection with raw materials programmes, where undesirable human settlement is to be avoided, and to often insupportable local traffic.

The **poor condition** of most state railway and **shipping operations** in many countries presents a **particular problem** with regard to the expansion of these transport facilities.

5. **Environment-oriented transport planning focuses attention** less on the planning of new transport routes and more on achieving **specific reductions in the environmental impact of existing traffic** and **improving existing transport by rail and ship. Fiscal** and **administrative measures** to encourage motor vehicles with low pollutant emissions, as well as **environment-oriented provisions for upkeep and expansion measures**, can help achieve these objectives.

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6. Tourism

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1. Scope

The aim of this brief is to highlight possible environmental impacts arising from the construction and further development of **facilities for tourism** and associated **activities** and to describe measures to avoid or minimise damage to the environment. Particular attention is given to **leisure and recreational tourism on the coast and inland** as well as **sight-seeing tourism**.

Facilities for tourism include all **buildings, open-air installations and infrastructural establishments** used to accommodate and look after tourists and service staff e.g. hotels, bungalows, club facilities, holiday villages, restaurants, souvenir shops etc. as well as **supply and disposal networks** for electricity, water, sewage, rubbish etc. In addition there are **special facilities** for activities such as swimming pools, golf courses, mini-golf areas and tennis courts, harbours and marinas and even airfields etc. Attention must also be paid to **activities which are not tied to particular facilities**, such as sea bathing, diving, wind-surfing etc., hiking, hill climbing, riding as well as sight-seeing tours to visit places of cultural interest and areas of outstanding natural beauty, national parks etc.

In recent years **tourism** has **developed dramatically**. The effect of this has been to trigger a variety of socio-economic, cultural and ecological **changes**. In many instances in the past **too little consideration** has been given to these factors, with a consequent influence on autochthonous population groups and damage to many virgin landscapes.

Exploitation of natural resources has had certain alarming **adverse effects on the natural environment** (e.g. lowering of water tables, threat to coral reefs etc.). On the other hand tourism contributes to an **improvement in foreign exchange earnings**, thereby facilitating the imposition of protective measures for areas of outstanding natural beauty to ensure their long-term conservation. It is therefore all the more important to minimise the negative environmental impacts of tourism projects in order to turn tourism into a **generally positive development factor**. This objective has also given rise to the expressions **"gentle tourism"** and "**sensitive tourism"**. There is no contradiction between respect for natural habitats and the culture and lifestyle of the local population in tourist areas and high recreational value and benefits for all those involved in tourism. In this context it has to be stressed that the problems which arise are not solely those caused by foreign tourists but can equally well be provoked by domestic tourists.

2. Environmental impacts and protective measures

The list below provides a summary of the main environmental impacts which may result from tourism projects.

- Engineering works for the purpose of developing facilities and the necessary infrastructure (drainage, infills, excavation, embankment work etc).
- Coastal erosion including beach erosion, destruction of coral reefs.
- Water supply (risk that ground water tables will fall).
- Water pollution resulting from untreated wastewater and sewage.
- Waste disposal.
- Power supply.
- Air quality and other climatic effects.
- Impairment of the natural landscape by buildings which are inappropriate in terms of location, size, external colour and style of construction.
- Socio-economic effects eg on regional economic structures, on the local labour market and on the lifestyle of the population affected by tourism projects.
- Conflicts over usage as a result of the displacement of traditional forms of land-use such as agriculture and fishing.
- Size and scale of facilities in relation to existing environmental factors, including any tourism facilities which may already exist (risk of over-exploitation of natural resources eg soil erosion).

In this context it must be stressed that eco-systems such as dunes, mangroves, savannas, animal reserves can be affected in many ways by these problems.

2.1 Soil, Relief, Geology

Land consumption constitutes a direct attack on the soil structure, and can be considerable depending on the size and scale of the facilities. It can also have a negative impact on other **land-use demands**, e.g. on the part of agriculture, forestry and water management, nature conservation and other forms of land use. In addition the ecological **functions of the soil** can be restricted with consequent **adverse effects on other forms of use**, particularly those resulting from the sealing over of areas with buildings, roads and the like.

Coastal erosion represents a serious problem with many additional complications. It can be triggered by construction projects and tourism activities on or near beaches, the removal of natural coastline protection and interference with the balance of materials on beaches.

In addition the danger exists that the **protective beach vegetation will be removed** and replaced in part by **plants inappropriate to that location** which provide less protection against soil erosion. Natural processes of sedimentation and the **coastal protection** provided by coral reefs can be very severely impaired by the removal of sand from river systems or from beaches and by the use of reef limes as building material (cf. 2.4). In order to protect sensitive coastal areas, sufficiently broad **buffer zones with vegetation appropriate to that particular location** should therefore be maintained or created and kept free from any sort of building. The use of coral limes as building material must be forbidden.

Erosion phenomena also occur in **mountainous areas** and are caused mainly by **deforestation** and the **destruction of ground cover vegetation** which is trampled down and camped on. This whole process is reinforced by the construction of hostels, cabins and paths. In order to avoid dangerous over-exploitation of peak areas, the greatest possible restraint should be shown in the construction of cable car systems and other technical means of transport to the top. The consequence of **a reduction in the forest area** is that when it rains or the snows melt **avalanches occur and river beds silt up**. It must also be remembered that in these extreme climatic conditions the vegetation takes a very long time to re-establish itself.

Soil compaction as well as soil erosion can also be provoked by the **construction of paths and tracks and inadequate maintenance of them** and by activities such as skiing, off-track use of mountain bikes, motor bikes or cars. In national parks inadequate maintenance of the paths and tracks can result in their **spreading out ever wider** with consequent adverse effects on the protective vegetation ground cover.

Similar consequences occur when tourists deviate from prescribed routes and pathways in order to look at flora and fauna from as close a vantage point as possible. Proposals for the **acceptable use** of national parks are contained in the **guidelines** on the tourist development of national parks produced by **IUCN** (McNeely et al.) These also contain sections on the establishment of accommodation units, roads and the like. Governments and organisers should provide tourists with **information on how to behave** in an environmentally acceptable manner and should, where applicable, issue **guidelines on behaviour**.

In addition, government authorities should introduce **environmental charges** for the use of sensitive eco-systems (e.g. national parks, walking tours) to provide finance for maintenance and repair work.

Pollution from refuse and excrement is yet another factor with adverse impacts on the soil. Apart from increasing its nutrient value a further side-effect can be an accretion of toxic substances.

To avoid this, tour operators and project managers should **collect waste separately and recycle it** according to its material value. Organic waste can be used as **compost**. **Educating** staff and tourists in how to behave in an environmentally acceptable manner is also of great importance.

2.2 Water balance

The **water balance is affected** by a **high degree of water consumption** and by pollution which **puts water quality at risk.**

While **water supply** is not normally a problem in temperate climates with large amounts of precipitation, it is a **major problem** in certain tropical and sub-tropical countries, especially on islands, in coastal areas and in semi-arid and arid areas with irregular rainfall.

Seasonal water consumption is particularly critical for tourism, because it rises very rapidly in periods of low rainfall which are preferred by tourists, thereby creating demand peaks. Consumption in a luxury hotel can be anywhere between 350 and 1200 litres per day per guest. This degree of variation is attributable to many factors including, for example, the location, the facilities, the water available, the way water is used and the use of recycled waste water. One can assume a **minimum requirement** of 250 litres per day per guest for a luxury hotel. The general assumption has to be that water consumption increases the more arid the area is. Whenever new tourism projects are being **planned** the extent and quality of existing **water reserves should be investigated** and then **compared** with the forecast monthly requirement. Account should also be taken of the requirement for staff and the native population, including any foreseeable increase in population.

The feasibility and effectiveness of connection to the **public water-supply system** must also be established. If wells are sunk thought must be given to the groundwater requirements of neighbours and the agricultural use of land. Connate groundwater supplies must be used sparingly. Consideration should be given as to whether **desalination plants** could be used for the supply of drinking water, although the **high energy requirement** and the necessity to remove materials from these plants must not be forgotten.

Water consumption can be **minimised** by taking the following measures:

Treatment and recycling of wastewater and use of non-potable water for outdoor watering purposes; collection and use of rain water; education of staff and tourists in the sparing use of water; application of modern technology to reduce water consumption (e.g. flush toilets) etc.

The need to protect groundwater supplies must be taken into account when large hotel and bungalow complexes are being planned and constructed. Care should be taken to **avoid sealing over** large surface areas.

A potentially serious problem is presented by the pollution of rivers, lakes and coastal waters from **refuse, oil residues** and the introduction of untreated **waste water and sewage** from tourism complexes. The discharge of organic and inorganic substances results in **oxygen depletion and eutrophication**, particularly in coastal inlets and lagoons with a low degree of water renewal. Physico-chemical and biological processes may result in the **accretion of toxic substances** in the sediment, in coral reefs (see also section 2.4) and in coastal fauna.

In order to **reduce waste water contamination,** detergents with phosphates, cleaning agents with chlorine and other **water-polluting materials should not be used**. Rainwater should be drained away separately, wastewater from sanitary installations, bathrooms and kitchens being **screened mechanically**, then **subjected to partial or full biological purification treatment**, depending on underground conditions and the quantities of waste water and sewage. The process may involve the use of microorganisms or phytographic settling and clarifying tanks. Special care must be taken to maintain these treatment facilities in perfect operating condition. Provided the degree of purification is satisfactory, sewage and waste water treated in this way can be used to **sprinkle** golf courses as well as parks and other green areas, while the slurry collected can be used as a **fertiliser** (see also the environmental brief on wastewater disposal).

2.3 Climate, air

The implementation of tourism projects may also **impair the micro- and mesoclimate.** Buildings as well as parking areas and other consolidated surfaces can give rise to disturbances, depending on the degree of sealing over (material and colouring), by heating up the immediate surroundings, and possibly leading to changes in air turbulence patterns.

Temperatures can be lowered, with a resultant improvement in the micro- and mesoclimate, by means of **extensive planting** and the use of lattice bricks on grassed areas. The aim in principle must be to **seal over the surface area as little as possible**.

The spread and **position of buildings** may interfere with the local **wind systems** (e.g. onshore and offshore wind system or mountain and valley wind systems), thus skyscrapers and other large buildings erected across the prevailing wind direction may form a barrier preventing or severely reducing air circulation. This is of particular significance in conurbations or where there is high-density development along coastlines or in valley areas.

When air circulation is reduced and combined with a high incidence of traffic, the result can be a **concentration of pollutants**. For these reasons **low-density and low-profile construction** should be planned, thus ensuring adequate natural ventilation; natural air paths must be maintained and greenery planted along their trajectory.

The **transport** of tourists and other tourism activities can have an adverse impact on air quality, particularly where the use of motor vehicles or aircraft is involved, and also as a result of moto-cross events, speedboat races and light aircraft displays. Events of this sort and sight-seeing tours to areas of cultural interest and outstanding natural beauty often involve a large amount of traffic and even traffic jams, resulting in **emissions** of nitric oxide, carbon dioxide etc. Measures should be taken to counter this by restricting the use of private cars and improvements to the **public transport system**. The amount of traffic can also be reduced by limiting the numbers of visitors and the days for sight-seeing.

2.4 Flora and fauna, eco-systems

Animal and plant life is affected immediately and directly when **natural vegetation is removed or altered** because of the construction of hotels, bungalows, sporting facilities and the like.

Depending on the scale and severity of such interference, the construction work may involve the elimination of rare animals and plants or an increase in the degree to which they are at risk, the isolation of natural habitats and the destruction of eco-systems. This can trigger major **consequential effects**, e.g. erosion, pollution of natural water sources, displacement of animal populations etc.

Inventories should therefore be taken before a project is implemented, with the aim of listing significant biotopes in good time and proposing measures to avoid or at least to neutralise such interference. The **assessment** is made according to its significance for the protection of species and biotopes and other ecological functions. Biotopes which deserve protection or which are particularly sensitive must not be eliminated or put at risk. **Less sensitive locations** should be established and put forward as alternatives.

Marine ecosystems are being seriously affected by the major growth in popularity of **seaside holidays**. Thus in coastal areas reeds, beach vegetation which provides stability and sand dunes are often removed. Lagoons are frequently filled in, thereby drastically reducing **mangrove forests**, so that hotels can be built and sand can be used as a building material. Damage is also caused by wastewater and sewage outfalls and by oil residues from leisure craft. Mangrove forests in particular have **many ecological functions**, e.g. a habitat for many different kinds of plants and animals, coastal protection, a transition zone between salt water and fresh water areas, encouragement of natural sedimentation etc.

Similar problems occur along open stretches of coastline not merely because beaches are polluted, but also because **corals are put at risk**. Excessive nitrogen from organic sewage and waste water can promote the growth of algae to the point of choking corals and other marine organisms, while bacteriological contamination as well as chemical and metal substances poison reef colonies and other marine eco-systems. As corals die off, **coastal current patterns can change** and **beach erosion** can increase.

One of the **central problems** arising as tourist facilities are constructed and operated is the degree to which eco-systems are **polluted by waste, sewage and waste water.** A precondition for approving tourism projects at the planning stage must therefore be the incorporation of an integral concept for reducing the amount of waste, recycling it and treating it in an environmentally acceptable manner together with the treatment of waste water. Projects must not be implemented if they are likely to produce adverse effects on or even threaten corals and other marine eco-systems.

Possible **measures** to reduce the amount of waste are:

- the use of environmentally friendly and biodegradable products, for example no canned drinks, disposable bottles or packaged foodstuffs and avoidance of plastic packaging whenever possible; instead the use of containers, deposits on bottles etc,
- recycling of organic waste in the composting system of each hotel
- education of tourists in environmentally friendly behaviour
- education of staff.

Corals are also put at risk when swimmers and divers **break off pieces of coral** for use as souvenirs and aquarium decoration. Corals are known to play a major part in their respective eco-systems.

Drainage work and **removal of groundwater** can have effects on **marsh biotopes**. As a result natural areas dry out and conditions in the natural habitat change, with consequences for the species living there.

Plant damage is often caused by **mechanical loads** such as walking, driving and camping (e.g.

trekking expeditions in the Himalayas and other high mountains).

Intensive practise of **water sports**, including incursions into shallow waters and sea and river banks, can disturb **feeding and nesting birds** and can **displace them**. Constant disturbance means that the nesting pattern becomes less dense and the birds have to move to undisturbed areas. Migratory birds which fly into certain areas to rest and feed are also driven away by the presence of people and boats.

Motor sport (e.g. moto-cross) as well as water sport can have a **highly adverse impact on fauna**. This includes: disturbance of ground nesting birds, destruction of nests, destruction of nesting areas in upright walls and displacement of birds and other types of animal.

Incursions of this sort can be minimised by means of the following **measures**, attention being paid in every case to the extent to which there can be **shared responsibility** between the authorities and tour operators:

- denial of access and protected area status for areas of outstanding natural beauty (no-go areas)
- ban on removal of corals and other rare animals and plants
- establishment of fixed transport routes
- restriction of numbers of tourists and excursions
- education of tourists.

National parks are frequently established in order to promote tourism. However, problems may arise if the **number of visitors** is too high, e.g.:

- major stress and disturbance for the animals (especially for lions and leopards) from too many photo safaris and excessive proximity to the vehicles as well as noise pollution,
- accidents involving animals due to excessive vehicle speeds,
- changes in natural instinctive behaviour because of feeding by tourists and familiarity with them,
- disturbance during breeding periods,
- intimidation of lions, buffalo and other animals from balloon safaris (stress behaviour),
- transmission of disease by people and waste matter,
- decimation of species by fires.

To reduce stresses of this nature the **viability** of each and every national park must be ascertained and a **management plan** drawn up on this basis for their exploitation.

2.5 Landscape

The landscape can be impaired directly by the **construction of tourism facilities**, and indirectly by the attendant construction or enlargement of **infrastructure facilities**, roads, airports, residential and industrial estates etc. A distinction must be made as to whether the planned location is to be constructed directly **adjacent to existing built-up areas** or holiday centres or is to be established in separate, largely **untouched areas of countryside.**

In built-up areas **visual blight** may result from too great an accumulation of building complexes which do not fit in with the environment either in terms of size or in terms of building material, style and colouring. The consequence is a permanent change in housing and settlement patterns and visual locations which were typical of the region.

To prevent developments of this sort, master plans as well as **structure planning and construction plans** should be devised so as to check over-development and excessive building. In the absence of appropriate legislation, **local building guidelines and urban development concepts** should be established whenever possible, or alternatively universally applicable urban planning guidelines laid down. It should also be established whether **bans on building** in certain areas must be enacted or construction work restricted by **the issue of licences**. Success can only be achieved by **monitoring compliance with planning edicts**.

In remote and largely untouched rural areas the countryside can be impaired by **individual buildings** unless these are integrated into the landscape. The corollary of desirable hillside locations is that the buildings erected can be seen from some distance. The construction of multi-storey buildings and the use of building materials not typical of the locality normally result in **blots** on the landscape.

This can be prevented by the construction of buildings in **typical local style** using **local**

materials. Local architects should be involved. For example, a design feature should be that buildings do not exceed the normal height of palm trees on tropical coasts. Intensive **use of greenery** and surrounding use of **typical local plants and trees** help to blend new buildings into the landscape. This is also applicable to the design of sporting and leisure facilities.

When **choosing a location** care should be taken not to remove or impair features which are typical of the landscape and cultural monuments. No building should take place in conservation areas or in other sensitive regions. Tourist facilities in national parks should only be erected at the extremities of the conservation area. Overdevelopment of the countryside as a result of ribbon development should also be prevented.

The proposals outlined above should also be taken into account in the **construction of paths, roads, bridges and the like.** Deep cuttings, high embankments and the dissection of natural valleys should be avoided.

2.6 Socio-cultural and socio-economic impacts and their effects on the environment

Tourist facilities and leisure activities can have major **consequential impacts** on socio-cultural and economic conditions and consequently on environmental media. Among the main **socio-cultural** effects are:

- changes in traditional values and patterns of behaviour of the indigenous population confronted with the standard of living of tourists (demonstrative effect):

the results may include resentment and aggression towards tourists.

- change of lifestyle for individual ethnic population groups due to the introduction of a money-based economy.
- marketing of traditional festivals and ceremonies by autochthonous population groups as tourist attractions. This can result in a loss of dignity for the indigenous population with traditional festivities becoming devoid of meaning.
- non-observance and infringement of religious traditions (taboos).
- identification by young people with Western examples which may be associated with a loss of regional identity. This promotes greater consumer orientation and can trigger criminality and violence.
- emergence of alcohol and drug abuse as well as prostitution allied to major health risks in women, children and men (eg AIDS).

Socio-economic structures can change in the immediate vicinity of tourist projects and - depending on the catchment area - can affect a complete region. In some cases this occurs at the planning stage with the construction of access roads, harbours, airports etc. and intensifies at the implementation and operational stages. The major **effects** are:

- influx of additional population resulting in a geographical concentration in particular areas and (unplanned) additions to conurbations, with an exacerbation of some of the adverse effects on the environment already mentioned.
- influx of traders and job-seekers who not only represent competition with the indigenous population but also increase regional disparities and trigger further

movements of population.

- removal of people from protected areas resulting in compulsory resettlement and the displacement of the indigenous population from its hunting areas.
- restricted exercise of traditional fishing practices following removal from private beaches and priority being given to use of the beaches for tourist purposes.
- loss of valuable rural areas for special agricultural crops (fruit, vegetables) as a result of the construction of hotel complexes, sporting facilities and accommodation for employees as well as major falls in the water table and saline contamination. This results in an exodus from agricultural professions and a move into the service sector. In addition this restricts supplies of appropriate products to the indigenous population and to tourists.
- scarcity of land, made even worse by tourism with land prices being driven up further.
- increase in the cost of living generally, e.g. for basic foodstuffs as a result of demand from tourists.
- increased imports of fuels to meet the power supply demands caused by tourists e.g. including the requirement for air conditioning systems. Increase in general energy costs as a result.
- excessive calls on existing health services.

These socio-cultural and socio-economic impacts cannot really be avoided, but must be minimised as far as possible. The following **measures** necessitating cooperation between project managers and the authorities can make a partial contribution towards these aims:

- participation by the affected population in the planning process and its implementation;
- compensatory measures provided by project managers;
- ways of life and traditions of the indigenous population being taken into consideration;
- training and further education of staff etc.;
- education of tourists.

In addition regulations can be issued such as:

- measures/laws to limit and control the misuse of alcohol and drugs, prostitution and corruption;
- economic regeneration of other areas in order to reduce additional migration;
- infrastructural measures deriving from national assistance programmes and development aid programmes.

Adverse environmental impacts derive both from tourist projects themselves as well as from the socio-economic restructuring which they trigger. The former are linked among other things to the requisite **infrastructural development** and the provision of mains facilities. For example, the transport of tourists often requires the construction of roads, airports and marinas, using up large areas of land.

Demand for foodstuffs from tourists can lead to **over-fishing** in coastal regions (decrease in fish population, impairment of ecological balance) and environmentally unacceptable methods of catching fish, e.g. use of dynamite). In Alpine regions this can lead to **over-grazing** and thence to **soil erosion**.

Major **influxes of population** can result in serious problems for **supply and disposal services** and increase the strain on all environmental media. It may be necessary to construct dams and power stations for **energy production**, resulting in further interference with the natural environment.

Unauthorised building by the migrant population attracted to national parks and other tourist areas should not be overlooked, as this can result in over-development of the countryside and, in extreme cases, in the ruination of once attractive landscapes.

3. Notes on the analysis and assessment of environmental impacts

When tourist facilities are established, care must be taken to ensure that they are **compatible** with national, regional and communal planning guidelines. For this purpose master plans, national development programmes and regional structure plans and programmes, as well as area plans and building development plans, must all be taken into account.

Assessment of potentially adverse effects on the environment can be undertaken on the basis of **qualitative and quantitative criteria.**

Quantitative methods should be applied to those environmental areas for which **measurable data** are available (e.g. water, air). In Germany, for example, the basis for this is provided by the maximum/minimum and guideline figures enshrined in many different laws, for example the *Bundesimmissionsschutzgesetz* [Federal Immission Control Act] together with the *Technische Anleitung (TA) Luft und Lrm* [Technical Instructions on Air Quality Control and Noise Abatement], the *Wasserhaushalts- und Abfallbeseitigungsgesetz* [the Federal Water Act and Waste Avoidance and Waste Management Act], the *Abwasserabgabenverordnung* [Wastewater Charges Ordinance] etc. Complementing these are the German DIN standards and VDI regulations of the Association of German Engineers. There are similar **environmental laws and programmes** in many countries, although they differ in terms of their content and other areas of emphasis. These should be drawn on for purposes of analysis and assessment. Account must also be taken of **international agreements and treaties**.

If there are no national legally-binding points of reference, **recommended values** stipulated by industrial countries, the EC and WHO, are often applied. Whereas the EC has compiled recommended values and guiding principles on soil, water and air, emphasis in the WHO has been on clean air and the quality of drinking water. All these should be applied taking due account of traditional standards of behaviour and local circumstances, as well as the availability of monitoring mechanisms.

There are no generally recognised quantitative standards for the environmental sectors of the animal and plant kingdoms and for landscapes, which means that assessments should be conducted on the basis of **qualitative predictions**. There are a number of **methodical models** for this purpose which have to be correspondingly adapted according to the particular natural features of the area.

Assessment criteria which are generally used for biotopes include for example species and structural diversity, incidence of rare or threatened species of animals and plants, rarity, natural characteristics and irreplaceability of habitats, representative quality etc. For **the visual landscape** the following factors are significant in assessment terms: individual elements and complexes which characterise the visual landscape, multiple structured areas, forms of natural relief, culturally historic forms of construction, forms of settlement and land usage, unspoiled nature and uniqueness of rural landscapes.

The environmental impacts triggered by tourist projects can be assessed generally and presented on the basis of **ecological risk analysis**. This means that the areas affected are assessed according to qualitative criteria as to their suitability, sensitivity and previous exposure to risks, the consequential effects being calculated on the basis of other landscape potential factors, as well as their geographical areas of impact. Planned risk alleviation measures are then taken into account in order to **assess the residual risk**.

When assessing environmental impacts it may be helpful to make a **comparison** with existing tourist facilities. This helps identify relevant factors which trigger adverse impacts on the environment as well as their degree of effectiveness.

Measures to avoid and alleviate planned incursions must also be worked out. These include: design and positioning of buildings in harmony with the landscape, use of traditional building styles, minimal usage of land and sealing-over of natural surfaces, measures to provide mains services and disposal of waste, provision of greenery around buildings, sympathetic landscaping etc. In addition valuable habitats must be maintained and looked after with their natural features. **Unavoidable adverse impacts** should be compensated to the extent that the natural environment is **not permanently impaired.**

Analysis and assessment of environmental impacts as defined in this environmental brief must also take place for limited/smaller tourism projects; the comprehensive nature and depth of scrutiny must be varied from case to case according to the relevance of the environmental impacts.

4. Interaction with other sectors

The construction of tourism facilities and tourist activities which then follow can have extensive effects on all aspects of the infrastructure.

Tourism projects can act as **economic factors** from as early as the planning and construction stage, and even more so once they are operational, exerting a considerable **influence** on the development of the surrounding area, industry, trade and commerce, agriculture and the creation of new housing developments. This means that there may be areas of overlap and even conflicts with the following sectors:

- "Spatial and Regional Planning",
- "Provision and Rehabilitation of Housing",
- "Planning of Locations for Trade and Industry" and
- "Rural Development"

There is also an indirect connection with "Public Facilities".

The development of tourism is also linked to **site access** and the provision of transport routes. Depending on their size and scale, tourism projects can provide the impetus for the construction or enlargement of roads, airports and other transport facilities. There are overlapping links with the environmental briefs:

Transport and Traffic Planning, Road Building and Maintenance, Road Traffic, Railways and Railway Operations, Airports, Inland Ports, Shipping on Inland Waterways, Ports and Harbours and Shipping.

Potential for conflict arises firstly from **additional atmospheric pollution and noise pollution** and secondly from **the various different usage requirements** on the part of agriculture and forestry, water supply management, nature conservation and other forms of land usage.

Finally there are close interactions between the development of an area for tourists and the **provision of mains services and waste disposal** for the immediate environment. The major **energy demand** can influence the overall consumption of energy in an entire region or even an entire country. This means that the energy planning brief should be taken into account.

Similar considerations apply to **water supply**, which should be secured at the outset by means of overall water framework planning:

Specific implementation depends on each location and involves either urban water supply or rural water supply.

In this context there may also be interaction with the sectors of rural and large-scale hydraulic engineering.

The collection, treatment and removal of **wastewater and waste materials** should either be the responsibility of the tourism project in question or should be integrated in the local waste disposal plan. Relevant references are to be found in the following environmental briefs:

- Wastewater Disposal and
- Solid Waste Disposal.

If tourist facilities are constructed in pedologically or geologically sensitive areas of landscape there may possibly be overlaps with the erosion control sector.

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5. Summary assessment of environmental relevance

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The construction of tourist facilities and/or the provision of tourist activities (e.g. trekking, safaris and the like) results in a **multiplicity of complex effects** on the environment. For example, tourism may **provide access** to areas which have hardly been developed so far or which are difficult to reach, thus triggering far-reaching socio-cultural and socio-economic **changes**. Depending on the size and scale of the project, there may be **permanent interference** with the soil and water structure, the plant and animal kingdom and the natural landscape. In the long term the **indirect consequences** can have even greater implications than the direct adverse impact of the project.

The many different aspects which have to be taken into account when tourism projects are involved necessitate **case by case treatment**, where assessment criteria must be weighted according to their significance. However, projects must be **rejected** if

- ecosystems worthy of special protection (e.g. corals, mangroves and other sensitive marine and terrestrial eco-systems) are to be removed or permanently impaired;
- the water supply cannot be guaranteed without major impacts on the natural environment, agriculture and the population affected;
- there is no plan for the avoidance and/or environmentally acceptable removal of waste and treatment of waste water and no specific measures for putting such a plan into action.

Apart from minimising adverse impacts on the environment, account must be taken of the direct and indirect socio-economic and socio-cultural consequences. It is particularly advantageous in the case of major projects and complex tourism projects to involve the **indigenous population** affected by the project in the planning process. This not only ensures a high degree of acceptance of the project but also induces requisite measures (e.g. provision of sanitary facilities, environmentally acceptable disposal of waste and waste water etc.) and economic restructuring. When alternatives are being examined it can equally be very helpful and valuable to involve the local population.

If the points made above are taken properly into account, **tourism projects** can have a **positive influence on the sustainable development** of a region or an entire country.

Survey of requisite stage by examination in the planning, implementation and use of tourism *facilities*

Area affected in the course of Environmental Impact Assessment	Land Relief Geology	Water	Climate
Description of area under examination (Inventory)	Land-use (2.1, 2.6); Biot. yield potential (2.1, 2.6); Risk of erosion (2.1); Land contamination (2.1); Waste accrual and disposal (2.1, 4.); Degree of sealing (2.1); Risk from volcanic activity and/or earthquakes	Existence of ground and surface water (2.2); Water consumption and supply (2.2, 4.); Water quality (2.2); Disposal (Type, capacities, 2.2, 4.).	Climactic conditions (2.3); Type and density of buildings (2.5); Volume of traffic (2.3, 2.6); Fresh air paths (2.3); Air quality (2.3, 2.6).

Project description (factors to be taken into account for planning purposes and location decisions)	Land requirement (2.1); Land-use (2.1); Relief variation (2.1); Building material (2.1); Unsuitable building along coastlines and shores (2.1); Disposal of solid waste and waste water (2.1).	Water requirement (2.2); Water supply (2.2); Disposal of solid waste and waste water (2.2); Water conservation areas (2.2); Use of untreated water (2.2).	Size, position, material composition and colour of buildings (2.2); Degree of sealing (2.1); Emissions (2.1); Plantations (2.3); Transport (2.3, 2.6).
Direct effects of project	Loss of land (2.1); Increased density and sealing (2.1); Risk of erosion (2.1); Change in soil quality (2.1).	Adverse effects on groundwater supplies and quality (2.1); Water quality and/or pollution (2.1); Floodlands and water	Heating up (2.3); Changes of air quality (2.3); Air turbulence (2.3);

		conservation areas developed (2.1).	Fresh air paths impeded (2.3).
Long-term consequential effects	Coastal erosion (2.1); Slope subsidence (2.1); Silting of rivers (2.1); Sand drifts, changes in soil quality (2.1).	Flooding (2.2); New groundwater accumulations (2.2); Groundwater salinisation (2.2); Groundwater and surface water quality, eutrophication (2.2, 2.6).	Adverse effects on micro-and mesoclimate (2.3); Disturbance of local wind systems (2.3); Pollutant emissions (2.3, 2.6).
Measures to alleviate/prevent environmental impacts	Minimisation of area used (2.1); Protection against erosion (2.1, 5.); Building materials (2.1); Waste reduction and recycling (2.1).	Reduced water consumption (2.2); Sewage treatment plants (2.2); Use of untreated water (2.2);	Minimising degree of sealing (2.3); Plantations (2.3); Fresh air paths (2.3);

		Waste reduction and recycling (2.2); Reduced degree of sealing (2.2).	Transport (2.3); Adapted planning of building dimensions (2.3).
Examination of alternatives	see project description	see project description	see project description

The numbers in brackets refer to the appropriate sections of this environmental brief

Flora Fauna Ecosystems	Landscape	Socio-economic, socio-cultural factors
Existence of species, societies and biotopes (2.4); Protected species and biotopes and those worth protecting, coral deposits, exploitation (2.4); Current loads (2.4);	Particular species typical of habitat and landscape (2.5); Relief forms (2.5); Settlement structure and character (2.5); Degree of development (2.5).	Population, income and economic structure (2.6, 4); Existence of ethnic population groups (2.6); Infrastructure (2.6, 4); Land usage (2.6);

Pot. Locations of valuable biotopes (2.4).		Development of tourism (2.6).
Removal of vegetation and habitats (qual. and quant. data) (2.4); Conservation areas (2.4); Building materials (coral, 2.4); Use of habitats (2.4); Leisure activities (2.4).	Size and design of buildings and external installations (2.5); Location (2.5); Building materials (2.5); Relief changes (2.1, 2.5); Establishment of greenery (2.5).	Staff requirement and training facilities (2.2, 2.6); Ethnic population groups affected (2.6); Mains services to and from staff housing areas (2.2, 2.6); Power and water requirements (2.6, 4); Conflicting usages (2.5, 4); Development measures (2.6, 4).
Changes in and removal of species and biotopes (2.4); Reduction of non-renewable eco-systems (2.4);	Changes to typical settlement patterns and visual locations (2.5); Displacement (2.5);	Influx of workforce and traders (2.6); Resettlement of ethnic population groups (2.6);

Isolation of biotopes (2.4); Pollution from solid and liquid waste (e.g. corals, 2.4); Removal of, damage to plants and animals (2.4); Disturbance and displacement of animals (2.4).	Failure to blend in with landscape (2.5); Removal/adverse effect on key elements (2.5).	Establishment of unauthorised settlements (2.6); Overloading of infrastructure (2.6); Mains services (2.6); Energy consumption (2.6).
Reduction in variety of species and biotopes (2.4); Threat and extinction of rare species, biotopes and ecosystems (2.4); Disturbance of population balance (2.4); Change in animal behaviour patterns (2.4);	Effects as above from construction/enlargement of infrastructural facilities, residential housing developments and the like (2.5, 2.6); Loss of typical landscape features (2.5).	Flight from land (2.6); Regional imbalance (2.6); Shortage of land (2.6); Increase in prices (2.6); Abandonment of traditional occupations (2.6); Abandonment of traditional values (2.6);

Decimation of animal species by removal to wild and transmission of diseases (2.4).		Import of foodstuffs (2.6, 4.); Energy consumption (2.6).
Maintenance and protection of valuable species, biotopes and ecosystems (2.4); Protection of corals (2.4); Minimum land usage (2.4); Creation of biotopes (2.4); Management plans (2.4); Compensatory and replacement measures (2.4).	Local building materials and adaptation of local building style (2.5); Preservation of biotopes (2.5); Plantations (2.5); Building to match contours of land (2.5); Development plans, building prohibitions, issue of licences (2.5).	Building of accommodation (2.6); Enlargement of infrastructure and provision of mains services (2.6, 4.); Participation of population (5.); Advancement of regional economy (4.); Training (2.2).
see project description	see project description	see project description

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7. Analysis, diagnosis, testing

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1. Scope

The scope of this section covers laboratory work for the sectors plant, animal and industrial production, research, education and health, including the procedures for analysis, diagnosis and testing.

The aim of analysis, diagnosis and testing is to obtain evidence of the presence of substances and organisms, identify causes of symptoms and test behavioural hypotheses. The results lead to the acquisition of additional knowledge, the development of products, assistance with education as well as the management of production processes and quality monitoring. Chemical, physico-chemical or biological methods are deployed analytically, in preparation

work and in applications.

Agents and equipment are used in specialised facilities, called laboratories, which are the main focus of this particular brief.

Laboratories are installed in buildings or in parts of buildings, and may also be designed in the form of mobile laboratories. Laboratories may also be installed on board ships. All these facilities provide laboratory apparatus and materials with protection against external elements such as weather conditions, noise, dust, theft etc.

A fully functional laboratory complex will also include the requisite storage areas, rooms for breeding test organisms, sanitary facilities, offices etc. The specific laboratory designation normally refers in the research field to the type of natural science which is mainly applied and in addition to the object of examination or the dominant method used.

Typical aims of laboratory work are:

- **acquisition of knowledge, product development**
- **establishment of assessment criteria**
- **confirmation of clinical trial diagnoses**
- **monitoring**
- **testing to reduce risks**
- **targeted genetic modifications to vegetable/animal matter**

- synthesis of chemical and biological raw materials
- increasing scope of health protection for people, animals and plants and
- promotion of agricultural production.

The method applied is the decisive feature for ensuring that test results can be repeated and are internationally comparable. The choice of method is specified, particularly when tests are required to be carried out for official bodies and authorities (cf. standard operating procedures, SOP or good laboratory practice, GLP).

The results of laboratory work have many different implications in everyday life and economic processes. Methods of monitoring environmental damage and preventing such damage are among the aspects which depend on their properly regulated operation. But laboratories may also be used in an attempt to develop aggressive, harmful research objectives, e.g. the development of biological and chemical weapons.

The technological standard should ensure that laboratories can be operated without any real risks arising. The risk of accidents increases if the equipment, operational and training standards are inadequate.

2. Environmental impacts and protective measures

2.1 Laboratories in general

The following distinctions should be made in terms of environmental impacts: after each heading typical representatives of that particular group are specified by way of example:

Laboratories using dangerous working materials (chemical laboratory)

- agro-chemicals laboratory (soil - plants - fodder)
- pesticide-residues laboratory, formulation control laboratory

Laboratories using biological agents:

- vaccines laboratory, diagnostic laboratory, e.g. microbiological, parasitological laboratory
- veterinary, human medicine laboratory
- genetic engineering laboratory
- animal feed laboratory

(sub-sector in vitro digestion/toxicology)

Laboratories using ionising radiation and radionuclides:

- X-ray laboratory
- isotope laboratory (medicine, agriculture, botany etc.)

The latter sub-sector is not discussed in brief because of its own particular complexity and potential for demarcation.

The aim of environmental protective measures is to avoid or to minimise damage to the health of staff and neighbours, as well as environmental damage. In terms of the design, installation and operation of laboratories this aim means that obvious dangers have to be taken into account by establishing a safety regime incorporating rules of behaviour and protective facilities. The major elements of these are listed below. In organisational terms, in order to monitor safety arrangements and facilities the recommended course of action is to train and integrate one or more employees as safety officers.

The products which are used or created often constitute dangerous working materials (toxic, caustic, irritant, potentially explosive, potentially inflammable, carcinogenic, sterilising, altering genetic make-up) and hazardous to the environment (persistent, accumulate in organisms etc.). Biological agents are frequently able to proliferate at will. Organisms which are specially bred and genetically manipulated possess new characteristics.

In laboratories the staff are the first to be exposed to these risks as a result of contact and immediate proximity. Moreover, environment is affected by emissions into the ambient atmosphere, the release of contaminated water and solid wastes. In general the small quantities involved mean that localised effects are likely. However, this is by no means a general observation; potential risks include toxic effects resulting from the dispersal of substances via surface water as well as the effects of virulent pathogens and ultra-toxic

materials, for example, regardless of the original amounts involved.

2.2 Chemical laboratories

In terms of environmental impacts, the main risk emanating from chemical laboratories is the uncontrolled release of materials and an increase in their concentration in the workplace and immediate vicinity until they become a health hazard. This applies to releases during normal operation of the laboratory, although major additional factors are deviations from the applicable regulations, accidents and, in particular, the risk of explosion.

The problem area may be sub-divided into four aspects:

- **handling of chemicals,**
- **equipment components and design of apparatus,**
- **structural installations and**
- **waste disposal.**

2.2.1 Handling of chemicals

Chemicals are either the materials being examined or they are used as auxiliary materials in experiments. They are used to promote reactions (catalysts), as solvents or as reactive agents.

There are many different areas of risk. Caustic and irritant gases irritate the skin, the mucus

membranes and the eyes. Blood, cell and nerve toxins e.g. carbon monoxide, prussic acid and suffocating gases (nitrogen, argon) act by displacing the oxygen in the air. Solvents are normally intoxicating even if they are not toxic or carcinogenic.

Many chemicals release toxic, flammable or highly inflammable gases. Where flammable fluids are concerned, the risk of fire as well as the risk of explosion must both be taken into account.

When working with chemicals delays in boiling are particularly likely when non-agitated fluids are heated and violent reactions from the substances brought together may be expected. In the case of other reactions highly toxic materials are released, such as prussic acid from alkali cyanides and acids or vapours when mercury is handled (in this respect see also Volume III: Compendium of Environmental Standards) (CES).

Substitution of dangerous chemicals by harmless or less dangerous substances is the safest way of obviating the dangers arising from substances which are a health risk. If this is not possible, substances which are harmful to health should be used whenever possible in sealed apparatus. If nonetheless chemicals of this nature have to be handled openly, fume hoods are required.

It is more appropriate to operate extractor hoses in situ where hazardous vapours are formed and are released. The extraction path must lead away from the atmosphere used by staff for breathing. Where harmful substances occur in gaseous form they should be fed through a gas

scrubber downstream from the extractor and bonded chemically.

Chemicals must be stored in appropriate containers and these must be marked as appropriate with danger symbols or signs, according to the contents and the risk category. Chemicals should not be stored and kept unnecessarily. Appropriate filling devices must be used to siphon off working quantities.

The appropriate protective equipment (rubber boots, rubber aprons, protective gloves, protective eye wear (goggles), nose masks etc.) must be available for working with acids, lyes and other aggressive chemicals. A major factor in laboratory safety and a precondition for properly conducted operation is a proper inventory and record system for chemicals (initial quantity, quantity used, storage location, separate waste disposal) and equipment.

Young people and pregnant women must not be employed in dangerous areas (e.g. handling carcinogenic substances, mutagens, highly toxic substances etc.).

The requisite protective measures (e.g. eyewash flask, first aid box, fire extinguisher) as well as rules of behaviour must be provided/displayed in the workplace and the procedures practised with staff. Areas of responsibility must be clearly allocated, and plans showing escape routes and safety drills must be on display in appropriate locations. The provision of separate amenities and showers is a precondition for personal hygiene when chemicals which pose a health risk are being handled.

2.2.2 Equipment components and construction of apparatus

The most frequent forms of accident in the laboratory are severe injuries from cuts involving broken or jagged glass. Glass breaks easily under concentrated local pressure and the application of lever forces (an important element for consideration when assessing equipment design). Improvisation in the use of apparatus often results in unpredictable reactions. Inadequate supports and incorrect fixings induce tensional forces and the collapse of parts or the entire piece of apparatus. When equipment breaks dangerous substances can escape and fires can easily occur. Hollow vessels made of glass are still frequently used for the insulation of coolants despite the risk of implosion; in this context the only vessels which should be used are hollow steel vessels fitted with a protective covering or highly insulated.

Equipment made of glass must be checked to ensure its integrity before use. Unsuitable pieces of apparatus, improvised equipment and cracked glass equipment must not be used. Apparatus must be properly secured and free of tension and may only be deployed in locations which are protected against external influences.

In order to prevent excessive pressure apparatus must be fitted with a pressure equalisation system relative to the external atmosphere. Reactions under high pressure may only be performed in suitable, undamaged pressure vessels. If there is any risk of exceeding the permissible operating temperature or the permissible working pressure, the test reaction must be suspended immediately.

Vacuum operations in glass equipment must only be conducted in suitable equipment. Apparatus containing combustible or thermally unstable substances may not be heated directly with an open flame. It must be possible to remove heating and cooling baths without dismantling the apparatus.

Gases are problematical in the laboratory since they easily escape from their containers and capable of forming toxic and highly combustible gas/air mixtures. The extractor system is not normally designed for large quantities of toxic and other gases. And if they are merely released, all that happens is that the problems are transferred from the laboratory. Potentially explosive gas/air mixtures may be formed when combustible fluids are being distilled and extracted. Ignition can easily result from electrostatic discharge.

Refrigerators without an air extraction system are not suitable for storing combustible fluids. In the case of many organic solvents peroxides form when air is added. These unconcentrated substances are enhanced in distillation residues and then cause major explosions.

Substances which give off combustible gases or vapours when dried may only be dried in explosion-proof drying cabinets. Combustible fluids must be stored separately from each other in explosion-proof refrigerators.

Accidents involving pressure gas cylinders may have appalling consequences. Accidents of this sort may be expected, for example, if fittings are installed and operated incorrectly, if the main release valve is stuck and is then forced open, or if the pressure gas flask is overheated

and overturned. Pressure vessels can explode; this risk applies particularly to vessels which have already been overloaded, corroded and damaged or when temperatures are excessive as well.

Pressure gas cylinders must be stored outside the laboratory or in well-ventilated containers which are insulated against heat. If technical conditions do not allow the laboratory to be supplied via a high-pressure pipe, pressure gas cylinders may only remain in the workplace for the period they are in use.

Pressure gas cylinders must be chained so that they do not overturn during transport and while in use. Toxic and corrosive gases should only be used in the laboratory in small pressure cylinders which must be located directly under an extractor hood when in use.

Moving parts in a piece of apparatus can catch clothing, hands and hair and can destroy pieces of equipment. Specially designed equipment is frequently unsafe due mainly to electric shocks from the equipment and power cables.

Electrical equipment must be in perfect working condition. For adaptation to situations prevailing in different countries the power supply to the laboratory must be given special protection against fluctuating voltage and mains failures. Costly analytical processes with many individual stages are increasingly being replaced by complex pieces of apparatus. Some of these processes have become the international standard. They are capital-intensive and complex in terms of maintenance and the provision of spare parts.

Where complex pieces of apparatus are involved, there must be a system for guaranteeing constant monitoring and maintenance (on-site servicing).

2.2.3 Structural installations

Small fires can spread to easily inflammable building materials. Building materials used are also frequently non-resistant to chemicals. Floor coverings or plastic casings tend to accumulate a static charge (ignition factor).

Hazardous substances can easily escape into the environment via air and water discharge pipes, especially if waste water is fed directly out into surface water. Simple waste water treatment plants are not able to deal with pollution caused by specific substances.

The outside world can be protected against dangerous side-effects by a more or less sealed enclosure depending on the characteristics of the various barriers and inlet and outlet pipes. In mobile laboratories particular care must be taken to ensure that laboratory waste is not discharged into the soil or subsoil, that laboratory effluent is not discharged into the groundwater system. Laboratories should not be established in drinking water catchment areas or in built-up areas. They should be constructed so as to resist earthquakes and other seismic disturbances. To comply with fire safety regulations fire resistant building materials must be used in laboratories. Lightning protection is also required.

Laboratory and storage rooms must be designed as walk-in sumps (5 - 10 cm deep) and may

not be connected to the mains sewage system. Laboratories require a separate waste water collection and treatment system. Flooring and work surfaces must be resistant to chlorinated hydrocarbons and acids and must be easy to clean. Power and other supply lines must be secured against the effects of accidents and clearly labelled. Electrical installations must be specially protected (e.g. against sparks).

In the tropics and sub-tropics direct sunlight leads to major heat problems in certain people and substances (spontaneous ignition when poured), and it can also cause greenhouse and lens effects. Lack of air and poor ventilation impair breathing. Lack of windows, poor lighting and closed doors have an adverse effect on eyesight and visual recognition. Laboratory work is adversely affected by noise and vibrations in equipment. If these conditions are permanent, effects on general psychological well-being are normally evident, the ability to concentrate is diminished and accidents constantly occur.

Laboratories in the tropics and sub-tropics require protection against the sun, good ventilation and, if appropriate, air conditioning.

Basic safety and other provisions must be guaranteed at the workplace (lighting, control of temperature, ventilation, safe, unimpeded emergency exits etc.). Technical measures must be given precedence over the use of personal safety equipment. Safety devices must be inspected regularly to ensure proper operation (emergency sprinklers, CO_2 fire extinguishers, first aid boxes).

2.2.4 Waste disposal

Laboratory waste consists of solids or fluids. Dangerous waste gases can be bound into fluids. Dust in stale air can be retained by filters (fluid and solid waste).

Where the products of reactions, filter residues and rinsing fluids are concerned, the products in question are normally dangerous chemical wastes, which in Germany have to be declared as special waste. Its disposal requires special monitoring equipment. Such waste presents a potential risk to the environment (soil, water, air), and hence also to human beings, animals and plants. Damage to materials and health results from explosions, fire or poisoning, particularly in the case of incomplete reactions, unprofessional storage and during transport. Fluid waste and gases can react in an unpredictable manner (due to accumulation of gas, heat, contamination).

Rational purchase and deployment of chemicals as well as regular stock control can reduce the accumulation of waste in the laboratory from the outset. All waste must be disposed of in an orderly fashion in order to prevent personal injuries, material damage and damage to the environment. This necessitates collecting laboratory waste, avoiding emissions and using appropriate chemical reactions to combine the minimum possible quantities of waste with other substances to convert them into harmless compounds. Acids and lyes must be neutralised, solvents can be recycled. Toxic substances in particular must not be disposed of with waste water but collected separately.

Organic solvent waste must be collected in unbreakable vessels holding a maximum of 10 litres. Heavy metal salts, filter and pump residues, used oil and chromo-sulphuric acid must all be collected separately. Spent mercury can be treated as a resource and removed for reprocessing.

Waste must be packed in the laboratory and marked. Documentary records must be kept of each disposal.

Staff must be trained in how to reduce waste and how to handle it safely. Compliance with the appropriate regulations must be monitored.

2.3 Laboratories using biological agents

The latter sub-sector is not dealt with as part of this brief on account of its complexity and autonomous nature.

Microorganisms, living cells, cell compounds and genetic components which can be replicated are used in the laboratory for the following purposes, among other things:

- **deployment or monitoring of organisms**
- **isolation of biologically active substances**
- **conduct of bio tests**
- **diagnosis**

- genetic engineering

- improvement in reproductive techniques.

These aims are served by the production of nutrients and live agents, the control of biological systems for the decomposition of substances, the exploitation of interaction between organisms (symbioses etc.) and the propagation of pathogenic agents and viruses in order to study their behaviour and means of controlling them.

The main risk involved in handling biological agents in the laboratory derives from the possible contamination of laboratory staff and infection of people, animals and plants outside the laboratory. In addition, damage is caused by the spread of new plants and animals to a particular region (new harmful organisms at the margins).

Protective measures are designed to prevent the release of pathogens, pests and poisons. They cover the professional execution of the work and subsequent disposal of waste.

New genome elements which can be replicated and produced by genetic engineering, as well as their vectors and host organisms, may embody a particularly potent risk, depending on their new characteristics. Not enough is yet known about the chances of survival of genetically altered organisms and other pathogens in the natural ecosystem. Once they have left the laboratory, circumstances may arise which render them uncontrollable or even irretrievable. This is an area in which new threats to the environment arise which cannot yet be fully ascertained. The requisite biological safety systems are still being elaborated and tested.

When handling genome elements which can be replicated it is very important to select host organisms and vectors on the basis of safety criteria. Pathogens can be replaced under certain circumstances by anti-pathogenic organisms in the same categories. Vaccination of laboratory staff is required in the case of certain pathogens. Biological waste from laboratories must be rendered harmless by burning or sterilisation.

The use of vectors for the transfer of haploid gene components is critical, particularly if these haploid genes are inadequately characterised, the specific host is not defined and the vectors chosen have their own transfer system as well as a high co-transfer rate and mobility.

Experiments on animals should be restricted to the greatest possible extent and care must be taken to ensure that laboratory animals are properly looked after.

If personal protective gear and laboratory safety devices are inadequate the handling of harmful organisms poses particular risks. The risk is that harmful organisms will be disseminated by laboratory staff and from the laboratory itself via wastewater, waste matter and extracted air. Protective devices and sluices can fail.

Effective physical or chemical sluices must be provided when biological agents which are hazardous to health and the environment are handled. In addition the appropriate protective gear must be available such as aprons, gloves, eye protectors, mouth masks (particularly in the case of spore-forming substances). These measures are effective when combined with the introduction of and compliance with rules of conduct. These include separate storage of work

clothes as well as the use of the various auxiliary devices provided. In order to guarantee laboratory safety in general, specific areas must be sealed off and physical barriers installed (closed doors, windows, treatment of extracted air).

3. Notes on the analysis and evaluation of environmental impacts

Analysis and evaluation of environmental impacts are concentrated on routines in the laboratory and external effects. Categorisation defines the sectors as follows:

- adverse effects on life forms (human, animal and plant health) and
- change in composition of species in terrestrial and aquatic environments.

Risk categorisations have already been carried out for many laboratory chemicals and organisms in use (cf. references and environmental brief on health and nutrition). Changes occur in the form of single incidents or accidents and continuous events. The degree of reversibility of processes is significant in terms of the change which occurs.

The Compendium of Environmental Standards (volume III) contains important notes relevant to the assessment of individual substances. As far as pollution in the workplace is concerned, the standards applied in Germany include, for example, maximum workplace concentrations (MAK), maximum immission concentrations (MIK), biological substance tolerances (BAT) and

technical guideline concentrations (TRK). There are also additional notes in the German Gefahrstoffverordnung [Ordinance on Hazardous Substances] of 1988 and in relevant publications by the EC and WHO. Note should also be taken of statements made by the US-American Environmental Protection Agency and the Occupational Safety and Health Agency (OSMA) which is subordinated to the National Institute of Health.

Particular emphasis in terms of safety of operations is enshrined in the following maxims:

- **reliability of the operating unit and of managers and supervisors,**
- **expertise on the part of managers and those responsible for safety,**
- **monitoring of general obligations to take proper precautionary measures, record them and prevent risks,**
- **guaranteed compliance with safety measures according to the most up-to- date scientific and technical standards, thereby minimising the risks,**
- **compliance with international agreements in respect of bans on chemical and biological weapons research and proliferation,**
- **compliance with general government safety and environmental regulations issued in the country where the laboratories are operated and recommendations which complement and exceed these regulations (comparison of international standards).**

4. Interaction with other sectors

Laboratories operate in all areas of agricultural production, environmental monitoring and health care. Operational strategies in these areas often depend on the due and proper operation of these laboratories.

In terms of protection against risks to health and the environment from the operation of laboratories themselves, there are very close interfaces with the following sectors:

- **plant production (in agriculture and forestry)**
- **plant protection, livestock farming**
- **veterinary services, animal protection**
- **fisheries and aquaculture**
- **health and nutrition**
- **disposal of hazardous waste**

Assessment is based on expert professional knowledge in these areas. The assessment has consequences for the sectors of chemistry, biology, construction of laboratory equipment and structural engineering.

5. Summary assessment of environmental relevance

Analysis, diagnosis and testing are discussed with reference to laboratories using dangerous

substances and those using biological agents.

Direct environmental impacts result from the construction and operation of laboratories on contact with dangerous substances and organisms. The health of staff can be affected by dust, chemically active agents (solids, liquids, gaseous matter), toxins, physical effects (pressures, blows, the effect of heat, electrical current) and by pathogens. The environment is affected by emissions of synthetic chemical substances produced and organisms via spent air, wastewater or waste materials.

The direct risks presented by a laboratory reside in the interaction of substances and organisms with defective containers, unsuitable equipment components and incorrect equipment assembly, as well as operating faults and inadequate safety measures.

Concrete predictions on the environmental impacts of laboratories and corresponding protective measures are only possible in the light of a precise knowledge of the structural engineering condition (protective and disposal installations) and the agents and equipment used.

Demarcation of laboratories as structural units and organisational entities enables the risks to health and the environment to be appraised and minimised by the combined effects of personal responsibility on the part of laboratory staff with staged external control and monitoring.

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8. Provision and rehabilitation of housing

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1. Scope

The object of providing housing is to satisfy the basic need for shelter. What shelter means and how the basic need for it is actually met will very much depend on local conditions and traditions and on how advanced the society is. Broadly speaking, what is meant by the provision of housing, in the narrow sense, is creating, maintaining and rehabilitating living accommodation and making available the items required for this purpose, namely building land, infrastructure (e.g. roads and railway lines etc., mass transport facilities, telecommunications, drinking water, facilities for disposing of waste and wastewater, and energy), building materials, construction technology, and finance. However, the provision of housing is not confined solely to making the actual accommodation available but also includes measures to create an environmentally acceptable residential habitat and the setting up of the other social, cultural and welfare facilities required (schools, health-care facilities, places of public assembly, shops, etc.)

In a wider sense, anything done to enable the inhabitants to play a fuller part in the social and economic life of the society helps to improve housing conditions. In particular, this includes steps taken to support self-help organisations, to establish secure rights where previous ownership is uncertain, to introduce amended rules and regulations and to promote employment and create sources of income.

Under existing economic and demographic conditions and in the light of current development trends, providing reasonable housing for urban populations is becoming a major problem. Today, a large number of families already live in unacceptable housing conditions. Though there may be local differences, the common factors which can be identified are these:

- **inadequate protection against the elements (e.g. rain, storms, solar radiation, cold), against hazards from the environment (e.g. noise, fire, pathogens, air pollution), and against expulsion,**
- **a residential habitat generating severe environmental stresses,**
- **overcrowding, leading to stressful situations, aggression and accidents and encouraging the spread of sickness and disease,**
- **building stock which is low-grade or presents health risks (dilapidated old buildings and slums, squatter settlements and dwellings constructed from scrap material or flimsy wood) and,**
- **a non-existent or inadequate technical and social infrastructure (e.g. an inadequate supply of drinking water, uncontrolled disposal of waste and wastewater, inadequate provision for schooling and medical care).**

In cases where towns undergo massive growth, this growth is often subject to only inadequate control by the authorities. Often there are no viable schemes for regional and urban development.

Programmes for providing housing are based on data on population growth, income distribution, size of households, distribution of population, etc. Inaccurate figures for population growth, for the size and state of the housing stock and for building by the private sector make it difficult to determine what need there is for housing to be built or rehabilitated.

In many countries, the growth of towns has not been evenly spread geographically. Internal growth and an increasing influx of migrants has meant a sudden spiralling in the demand for housing in conurbations. Where housebuilding policy has concentrated on meeting the demand by building new housing it has proved particularly bad at meeting the growing demand for low-cost housing. The ever larger supply-side shortfall in the field of low-cost housing has therefore caused existing towns to become overpopulated and slums to be created, particularly in long-established areas of old houses. At the same time there has been an extensive wave of illegal occupation of land combined with the erection of shanty housing.

Today, the main aims in providing housing are not only to create fresh accommodation within the framework of regional and urban development but also to deal with seriously bad housing conditions by upgrading the housing stock. In rehabilitating housing, another of the goals being pursued is to slow down changes in the social mix, which in the areas concerned

normally tend to be in one direction only, and in this way to achieve a better social balance.

2. Environmental impacts and protective measures

Projects aimed at providing or rehabilitating housing have an impact on the environment through the building activities to which they give rise; certain important aspects of these are outlined below.

2.1 Development of areas of new housing

There are problems that are difficult or even impossible to solve when housing is being rehabilitated and these are the problems that have to be anticipated when planning new housing. The techniques and planning measures required for this purpose are familiar and well established; the main ones and their accompanying environmental impacts are briefly outlined below.

Allocating areas for building normally entails a change in the existing land use and a rise in the consumption of raw materials; hence, land suitable for agriculture, areas of forest and woodland, and ground covering mineral deposits should not be built on if at all possible. Farmland in peri-urban areas often serves to supply the needs of the urban population and should not be adversely affected by steps taken to develop the towns. Areas of forest and

woodland close to towns represent a valuable resource deserving of protection. Such areas perform climatic and hydrologic functions, act as a recreational resource and often form a source of supply for fuel, building materials and drinking water.

The physical location of public utilities and sources of employment is dealt with in other environmental briefs such as

- **Planning of Locations for Trade and Industry**
- **Public Facilities - Schools, Health Care, Hospitals.**

Particularly for housing, closeness to jobs is often an important location determinant.

Cheap building land will often be available well away from towns. This however not only means a change to the existing use of the land but also creates a problem in that more transport services will be needed. Once built on, such land may, often quite deliberately, create a need for land to be switched to other industrial or commercial uses. This being the case, land-use regulations will be needed as part of planning law to control possible emissions and the demand for land.

New areas of housing mean a redistribution of the demand for water, but they may equally well give rise to increases in this demand, to greater amounts of wastewater and solid wastes and to a need for the appropriate infrastructure to be provided. There will also be a rise in the volume of traffic. When planning new areas of housing, the regional supply and disposal

facilities will need to be considered.

Insects, which act as vectors of many diseases, constitute a major risk to the health of inhabitants. Poor sanitation, standing wastewater, and even open water tanks produce ideal breeding grounds for insect pests. Insects can be successfully combatted at lower cost by preventative action than by the use of chemicals for example. The organised collection of solid waste, regular maintenance of open drains and suitable domestic sanitary systems such as ventilated latrines will reduce health risks in this way. Protection against insects inside buildings can be obtained by, for example, extra nets covering doors and windows. Apart from the question of funding for reasonable supply and disposal facilities, another question of crucial importance is keeping them in good working condition (maintenance).

Personal and household hygiene is another prerequisite for reducing disease. As well as the physical requirements mentioned above, public information on the importance of hygiene can play a major role in improving health; in this connection it should be remembered that, depending on the country, between 30 and 60% of the heads of households in slum areas and squatter settlements are women. In buildings, it is in the areas of food preparation and storage and number of occupants that important hygienic requirements have to be satisfied. Where possible there should be a separate kitchen with an adequate supply of good quality water and good facilities for wastewater drainage.

Animal raising is common in urban areas and forms a source of extra income. However, animals can also transmit disease; children in particular should be prevented from coming

into contact with dung, and animals should be kept away from areas used for utilities and other services or for disposal purposes, such as rubbish dumps for example.

Polluted air is another thing that puts human health at risk. Pollution sources in urban areas are domestic heat and energy production (particularly where coal is burnt), the burning of solid waste, road traffic, and industrial emissions. Selecting suitable locations for areas of new housing and analysing possible ways of improving the local habitat (e.g. planting of vegetation, aeration) for rehabilitation projects are some of the ways in which improvements can be effected.

Like air pollution, noise too is a health risk but it is one that is rarely given its proper weight. Soundproofing, in buildings for example, is expensive. Where the source cannot be eliminated or its output reduced, viable noise-protection options are ensuring adequate separation from the source of the noise and, where required, breaking the transmission path by erecting embankments.

2.2 Rehabilitation of housing

The purpose of rehabilitation projects is restrained urban renewal. They are carried out to improve living conditions in existing uncontrolled settlements and slums. In so doing, they avoid demolition and re-settlement wherever possible and instead take advantage of the existing social structures and housing to initiate or accelerate the process of building an integrated community.

Poor sanitation is a major problem in many existing settlements. Hence the improvement of hygiene conditions must be a priority task; this includes providing and developing a reliable supply of water and ensuring controlled disposal of solid waste and wastewater. Although such projects do, in the main, improve the environmental situation in settlements, they need to be carefully planned and their running needs to be meticulously monitored if they are not to damage the environment. The following environmental briefs in particular offer detailed planning notes for this purpose:

- **Urban Water Supply**
- **Wastewater Disposal (and rainwater) - collection, treatment, disposal, removal)**
- **Solid Waste Disposal - collection, treatment, disposal.**

While it is true that high-density housing has beneficial effects on infrastructural costs, land uptake, etc., it also creates problems, such as greater surface runoff and hence the risk of flooding, problems with water supply and disposal of wastewater and solid waste, aggravation of the consequences of natural disasters, and a less satisfactory habitat and hence less satisfactory hygiene conditions.

Another objective of rehabilitation projects is to improve the housing stock. Dilapidated old buildings and above all the buildings in squatter settlements are often a health risk. Preference should be given to using local building materials, which may also create jobs. For self-built housing, not only is the flexible application of planning and building standards necessary but advice from building consultants is needed to prevent hazards and additional

costs.

Raising the standard of the infrastructure in residential settlements also includes the putting down of facilities for public movement such as roads, footways, squares, flights of steps, etc.; such operations increase the sealed ground surface and hence contribute to greater surface runoff. Theses areas need to be drained. The provision of a road infrastructure increases traffic in areas where there may not have been much previously. In this case regulations to limit, say, motorised private transport may be considered for the purpose of cutting immissions. However, given the importance people attach to private transport, there are severe constraints on whether such regulations can in fact be introduced (see the environmental brief Transport and Traffic Planning).

It will often be necessary to work towards providing lower standards of development, such as only a single access road per block for the fire services and refuse collection rather than a fully developed system of roads.

2.3 Locational factors and planning

It is in the areas of location selection, design of settlement and infrastructure, and type of dwelling that the environmental impacts of housing projects lie. Not only natural factors but also the activities of planners need to be considered. Often, in the very areas which are out of the question for development or the building of new dwellings, there may already be (illegal) squatter settlements and hence a requirement for rehabilitation.

Many countries are situated in zones subject to earthquakes, volcanic eruptions, floods, and landslips caused by erosion. The regions where the majority of such natural hazards occur are known; seldom however can their occurrence be predicted. Early warning times of a few days are exceptional; it is often a matter of hours. It is therefore important to have regional monitoring systems, for appropriate protective precautions to have been taken, and for expertise in disaster prevention and rescue to be readily available.

Many large towns are particularly at risk because, for historical reasons, they are often situated on estuaries, at river crossings, on deltas, or in basin-like depressions. When this is the case, locations where the geomorphological situation is better should be sought, at least when satellite settlements are going to be established. Possible consequences of earthquakes, volcanic eruptions and storms are the destruction of buildings and parts of the infrastructure, earth slips, floods and fire (e.g. as a result of damage to electrical systems). Locations at risk from natural phenomena should be avoided wherever possible for housing projects. Where this is not possible or where built-up areas already exist, special precautions should be taken in respect of design of settlement and infrastructure and types of dwelling. When the layout of the settlement is being decided, high-density housing should be placed in low-risk areas, and the plans must provide adequate access for rescue vehicles. Parts of the infrastructure particularly at risk such as the water supply, the wastewater discharge system and the electricity supply should be designed to be hazard-resistant to local standards where these exist; in some cases this will make them considerably more expensive.

The buildings should have hazard-resistant structures and where possible structural

provisions of this kind should be incorporated into the existing buildings. Examples of such provisions are wooden frames and solid roofing with no sharp edges; when blown off in storms, sharp-edged sheet metal roofing creates a further hazard. However, such provisions must be weighed against the cost involved, particularly when applied to existing buildings.

Although hilly country offers greater protection from flooding there is still the risk of landslides and mud flows. Slopes in zones subject to erosion and river banks are often a favourite location for uncontrolled settlements; in such cases the financial impact of reducing the risk has to be weighed against the cost of opting for an alternative location. Buildings on steep slopes will need to be suitably anchored and supported.

Where build-up areas are sited on a rocky subgrade, this creates drainage problems. It costs more to lay the services infrastructure underground and sanitary systems are more difficult to install because of the need for machinery to be used.

On wetlands or in lake-side areas (where elevated pile foundations will be needed), building costs go up, and such areas should not be considered as possible locations. Wetlands have to be drained or filled; as well as the ecological consequences of doing this, additional costs will be incurred for suitable machinery and the opportunities for self-help are limited. Considerable problems will also arise with hygiene.

As well as the possible adverse nature of the ground described above, another problem that particularly affects the siting of dwellings is old pits and dumps for the disposal of solid waste

and abandoned industrial sites, collectively called contaminated sites. Hazards that exist at places like these are subsidences due to inadequate compacting, fires or explosions resulting from methane release, unpleasant odours and contamination of water. For such areas to be used for lightweight building or rehabilitation, comprehensive appraisals of the potential hazards will be needed.

Floods are a seasonal phenomenon caused both by heavy precipitation and by storms and their effects are aggravated by the sealing of the ground surface which is a necessary part of settlement. They result in contamination of drinking water, overflow of the private and public discharge and drainage infrastructure, erosion, damage to buildings, an increase in the breeding grounds for disease-carrying insect pests, and, in the worst case, fatalities. Though cheap, land subject to periodic flooding requires large investments in drainage systems and protective structures. Incorrect drainage may lead to groundwater pollution. Open drains for surface water, though simple to lay, can easily be blocked by the sediment load, plant growth and uncontrolled waste disposal; constant cleaning of the drainage system is also necessary on health grounds. Individual buildings can be protected from flooding by building them on platforms or elevated piles.

Vectors of infectious diseases (attracted by human and animal excrement and wastewater), toxic chemicals (from local industry), and natural constituents such as very high salt or metal contents are causes of water pollution. The requisite cleaning techniques, though known, are often impossible to finance due to their high running costs. What is important is for drinking water to be adequately protected from pollution at source, in the pipes and at the takeoff

points.

Land allocation has an important part to play in dealing with the environmental aspects of housing projects. By suitably allocating land to uses that do not interfere with one another or do so to only a minor degree, or by separating mutually intrusive uses in rehabilitation projects, it is normally possible to reduce problems with immissions. By selecting appropriate locations for communal amenities and businesses and by planning transport capacities to match, it is possible to reduce the transport services required and hence energy consumption and immissions.

Building density is an important factor in housing projects and one that creates environmental problems. The closer together the buildings, the smaller the amount of unoccupied space left for grassed areas, trees or other plant cover. This affects the local microclimate, the hydrologic cycle and the quality of the air. The setting aside of ground for open spaces is thus an effective way of improving the environmental situation in residential areas, especially in hot and humid climates. However, there are costs involved because the open spaces take up land that could otherwise be built on and they have to be looked after if they are to go on performing their function.

A widespread practice in building projects is to remove existing trees from land for dwellings in the construction phase. This should be avoided as far as possible.

Climatic design principles, based on natural ventilation, should be carefully applied in

residential buildings and buildings for other purposes. If there is no way of avoiding air-conditioning systems, then care must be taken to see that substitutes are used for hydro-chloro-fluoro-carbons (HCFC's).

The use of energy in homes will depend on disposable income and the energy resources available. For high and middle income groups, the most widely used forms of energy are electricity and gas bottles. In areas where incomes are low, traditional energy resources such as wood, kerosene, charcoal, refuse and dung are widely used. These however are a major source of air pollution. The burning of firewood and charcoal is one of the main causes of deforestation and subsequent problems with erosion. One radical alternative to such fuels is the use of solar energy, which can be employed for heating, cooking or, via solar cells, for generating electricity. There is vast potential here for use in urban areas too (see also the environmental brief Renewable Sources of Energy).

To avoid existing or anticipated bottlenecks in the supply of building materials, to increase productivity in terms of finished dwellings and to cut costs, thought should be given to what building materials and techniques are going to be used. Metal roofs for example, though easy to install and maintain, create climatic problems in buildings and, where they have to be imported, tie up foreign currency. The use of suitable local materials may help to improve housing conditions and will boost the local economy. The point at which the unrestricted use of local materials becomes unacceptable is where resources become over-exploited or where it may create health risks, such as when asbestos-containing materials are used. Although there is very little that individual projects can do to influence product ranges, any

opportunities that occur to do so should be exploited to the full.

The gearing of buildings and rooms to the cultural customs of the population, and the aesthetic standards of such buildings and rooms, are important factors that may cause social impacts. Studies of the cultural values, ways of life and physical and functional requirements of the target group (not just the way in which areas in the settlement are allocated to uses such as residential, shops and religious activities, but also the functional layout of apartments or houses) will provide pointers in the above respects for shaping the project.

Changing the use of an area always has impacts on neighbouring areas; these need to be catered for by means of precautionary planning. Where for example there are areas at risk from erosion close to areas of new housing, the latter areas will need protection. The same will be true where there are areas of forest or woodland situated close to residential areas where the residents produce their energy in traditional ways.

Of all the members of a family, women, often in the capacity of head of the household, spend the most time working in the home and they are thus the main beneficiaries of improvements in housing. This is why special consideration must be given to their interests in the course of planning and implementation.

3. Notes on the analysis and evaluation of environmental impacts

German planning law and building regulations, together with the complementary rules and regulations governing immissions, plus the body of law relating to nature and landscape preservation and water/wastewater and solid waste, form a comprehensive legal armoury; but to operate successfully they need control mechanisms and sanctions. These however are very complicated and expensive and it is therefore impossible for them to be adopted in many countries when even the basic legal framework is lacking.

Nevertheless, they are based on principles of planning which do not alter with different geographical zones and here are some of these principles:

- **bring together uses that do not interfere with one another or do so to only a minor degree,**
- **keep a distance between uses that do interfere with one another,**
- **prevent, reduce and recycle solid waste.**

(see the *Bundesimmissionsschutzgesetz* [Federal Immission Control Act], the *Abstandserla* [separation decree] of the state of North-Rhine/Westphalia, the body of law relating to solid waste, etc.). Yet even German law, comprehensive though it is, confines itself to general statements in certain areas where no universally applicable guideline values or standards exist and where a verdict has to be reached in the light of the individual circumstances. A typical example of this is the sensible allocation and mixing of land for building and land for open spaces. There is no question that this should be done, but it may be difficult to achieve in practice because there is no provision for it in the law. This is particularly important in

countries where the land does not have the benefit of a legal framework to protect it.

It is often the case that, though the World Health Organization (WHO) guideline values may be adopted as reference parameters for appraisals of air quality or the basic need for a supply of hygienically acceptable water, nothing is done to ensure that these values are met. Not just in the areas of land and water but in that of flora and fauna too, what are crucial are national laws and, where in place, international conventions. From them can be extracted basic requirements for use in assessing housing projects.

Where they exist, relevant local planning regulations are an essential prerequisite for environmentally acceptable housing provision. Urban development guidelines, housebuilding schemes, the stated objectives of rehabilitation programmes, town planning law and the local building regulations often include a large number of provisions relevant to the environment. A further point that should be made is that received behavioural norms often correspond to coded form, and express modes of behaviour that are in tune with the environment and they may thus be accorded a standing equivalent to that of guidelines. Ways of life, settlement practices and types of economic activity all have a crucial bearing on modes of behaviour of this kind.

4. Interaction with other sectors

Cross-sectoral projects such as housing provision affect planning in many other sectors. Cross references have already been made at the appropriate points in the text.

In the same way, housing projects are included in master planning schemes that may have repercussions on the organisation of the projects. This is the case with, for example, spatial and regional planning, overall energy planning and water framework planning.

5. Summary assessment of environmental relevance

The need for shelter is a basic need which, due to economic constraints, may not be acceptably met for certain sections of the population. Projects to rehabilitate housing settlements and the allocation of land for areas of new housing both involve many environmental impacts and the environment may likewise affect such projects in many ways. With projects of this type, it is not a question of looking for radical alternative solutions in order to achieve the given goals. What is important is that in planning and executing housing projects, full allowance should be made for the areas of potential conflict with the environment described above in order to determine how the projects can be executed with the least harm to the environment. It is particularly important that programmes for providing housing with utility and other services should be embodied in a scheme for balanced spatial and housing development that includes the promotion of regional centres.

In the past, provision of housing by the state often concentrated mainly on overcoming housing shortages in large towns, caused amongst other things by the flight from the land and the lack of jobs in the towns. This was done by mass producing dwellings on the lines adopted in the industrialised countries, but often no thought was given to analysing the risks involved and to heading off any secondary effects (such as the need to dispose of wastewater and solid waste). In so doing it started processes of change in the natural environment and in human society which led to serious undesirable developments. The results of an unbalanced housing provision policy of this kind were not only greater uptake of land and extensive pollution of the soil, water and air but also social erosion, greater poverty, more crime and the destruction of traditional ways of life.

Where housing is provided by the state, programmes for modernising and maintaining the housing stock and for rehabilitating residential areas must allow opportunities and avenues for staving off undesirable developments in society and reducing environmental stress. An employment policy which acknowledges self-help in the provision of housing as an effective way of reducing material poverty can be of considerable assistance in providing housing and protecting the environment.

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9. Public facilities - schools, health care, hospitals -

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1. Scope

The measures dealt with in the present environmental brief have to do with the provision of what is also known as "physical infrastructure". Their goals lie in the creation and development of facilities

- **for education and training**
- **and health care**

and thus in two areas of primary importance for the public and private provision of essential services.

The present brief does not go into the philosophy of environmental education but the importance of such education should not be overlooked.

Education and training covers projects both in the field of education and training for children and young people and in the field of adult education and training. In both cases, the main focus needs to be on education and training to instill and develop job skills.

The field of health care falls into two sub-divisions:

Improving hygiene and prophylactic health care (e.g. immunisation against infectious diseases) and providing health education and advice. Particular activities which come under these headings include advising on diet and the family, creating and developing facilities for nursing and supply such as facilities for supplying the disabled with drugs, and the training and deployment of medical personnel. In the present brief it is projects that fall within the field definable as "planning, construction and running of education, training and health care facilities" that are considered from the point of view of their adverse environmental impacts.

The impact of projects in the field of health care, education and training is to alter the structure of a country and not least the thinking and feelings of its people and their conception of themselves. It seems essential to proceed with, above all, due consideration for

> **- the special ethnological character and diversity of the given country and its different ways of life, commercial and industrial practices and modes of behaviour, its understanding of nature and the environment, and its cultural and religious traditions,**
> **- the perceptiveness and comprehension of the people concerned, and**
> **- their willingness to act to meet the demands of changes that are environmentally relevant.**

2. Environmental impacts and protective measures

The environmental impacts that can be expected to occur during the planning, building and use of educational, training and health care facilities can be classified by their differing causes:

- **impacts on projects from the natural environment,**
- **impacts on the environment generated by projects.**

These different impacts will be looked at in detail below, and also described will be protective measures (see sections 2.1.4 and 2.2.4) that can be adopted to moderate, compensate for or even totally avoid adverse environmental impacts when planning, building and using educational, training and health care facilities.

2.1 Educational and training facilities and their environment

2.1.1 Impacts on projects from the natural environment

The factors which should be covered in a study in this case are the following:

- **topographical conditions (e.g. mountainous, desert or marshy terrain, lagoons),**
- **climate (e.g. wind directions and strength, pollution by dust and sand, solar radiation, humidity, air circulation),**
- **location and ground conditions (e.g. soil strength, risk of earthquakes and volcanic eruptions, marshy areas, areas subject to flooding),**
- **fauna (e.g. prevalence of fauna that cause or transmit disease such as the anopheles**

mosquito, tsetse fly, black fly, rats, poisonous snakes, etc.).

2.1.2 Impacts on the environment from the man-made environment

These environmental impacts take the form of noise, and air, water and soil pollution. They are generated by traffic, industrial and commercial areas and private households, and by agricultural production, the generation of energy and the disposal of wastewater and solid waste.

2.1.3 Impacts on the environment from projects

Environment impacts on the natural environment that result from training and educational facilities are caused by:

- **land uptake,**
- **sealing (of the ground surface by concrete, asphalted areas etc.),**
- **traffic (as a result of development, stationary traffic),**
- **solid waste,**
- **water pollution,**
- **noise (machines, equipment and concentrations of human beings).**

Training and educational facilities having particular environmental relevance are:

- schools with teaching laboratories,
- training centres providing job training,
- laboratory and research facilities providing training in engineering, chemistry, biology, medicine and physics.

If they are incorrectly mounted or misused, the use of laboratory materials and equipment and teaching aids (chemicals, technical equipment and machinery etc.) may produce physical and chemical changes in the air, groundwater and soil whose severity and extent is difficult to control (see the relevant brief in this connection).

Sports facilities, which are generally sited close to schools, exert environmental impacts over and above those of the schools themselves due to:

- the levelling (and often the sealing over) of relatively large areas of land,
- changes in the soil conditions caused by stripping of the top soil and laying of a new soil profile,
- additional noise emissions,
- a demand for extra energy and land for transport purposes.

New types of educational and training curriculum and the resulting changes in the educational and training organisations may also bring changes in social behaviour with them.

2.1.4 Protective measures and recommendations

Protective and corrective measures to mitigate or prevent adverse effects on the environment will be needed when the location of training and educational facilities is being decided and while they are being constructed and run.

- **Determining location**

Educational and training facilities for providing a basic education inside or outside schools are considered part of the residential infrastructure and need to be erected within easy reach of housing, normally inside residential settlements.

When new residential settlements are being planned, the setting up of the residential infrastructure generally forms an integral part of the scheme. In this way, important prerequisites for environment-friendly location fixing have already been met, such as availability of connections to supply and discharge pipes and cables (for water, wastewater and energy), incorporation in the footway and road network, availability of building materials, etc. It is important to avoid locations for training and educational facilities, and hence for residential settlements, where there are hazards to the project arising from geological, topographical or climatic conditions or from fauna (see section 2.1.1). Also to be ruled out are locations that are subject to industrial or commercial emissions, that are adversely affected by traffic, energy producing plants or agricultural production, or that present a particular potential hazard due to the absence of facilities for disposing of wastewater and solid waste or their closeness to waste dumps (see section 2.1.2). The location of a facility within residential settlements, and also within rehabilitation areas, must be selected in such a way that the

facility is easy to reach, i.e. only a small amount of time and money has to be spent on the journey to it. At the same time, the location selected must be such as to ensure that the noise, traffic and other adverse effects caused by the facility itself at least remain within reasonable limits (see section 2.1.3). The main thing that needs to be established when existing residential areas are to be provided with educational and training facilities is whether it is justified in the medium or long term for the provision to be made in situ, i.e. a check must be made to see whether it is possible for the residential area to remain where it is in view of its position in an area at risk from the natural or man-made environment. If educational and training facilities are to be provided for residential settlements in areas subject to environmental stress, alternative locations will have to be found for the facilities. These should not only ensure low levels of environmental stress but should also ensure that the facilities can be reached easily in the long term by the population for whom they are provided.

- **Protective and corrective provisions in design and construction**

By means of the overall project design and the way in which the plot of land is used, and by the division into blocks and the positioning of the blocks on the plot, it will be possible, to a large extent, to guard against incoming adverse effects from the outside environment. At the same time it will be possible, within certain limits, to so arrange the design as to avoid or reduce any adverse outgoing environmental impacts from the project.

The use and refinement of customary local principles of design and building materials can make a further contribution to the environmentally acceptable installation of educational and

training facilities, provided the following criteria are met:

- **a better microclimate at the location, achieved inter alia by using traditional artisanal skills,**
- **fitting out to suit the climate.**

Sanitary areas in schools should be so designed as to ensure that environmentally acceptable disposal of an adequate volume of material will be possible in the long term. Schools with laboratory facilities (see section 2.1.3) should be designed with a particular eye to the greater risks they pose to the environment (due to toxic materials finding their way into the sanitary area and to misuse and incorrect mounting).

When laying out the grounds of schools and the associated sports grounds, the following points need to be borne in mind:

- **avoid the need for large amounts of water or energy to be used for the laying out or for future upkeep,**
- **prevent any soil erosion,**
- **avoid bodies of dormant water and areas of plant life likely to attract insects that are undesirable on health grounds.**

2.2 Health care facilities and their environment

2.2.1 Impacts from the natural environment

It is the natural conditions of existence that mould the way of life, behaviour and modes of economic activity of human beings. Among the determining factors are weather conditions, which vary with the seasons and the given climatic zone, availability of water, and changes in flora and fauna in response to climate and water (see section 2.1.1). These factors form the defining conditions for the health, well-being, fitness and diseases of human beings. Particularly at risk is the health of people living in regions where the pathogens causing malaria, cholera, bilharzia and onchocerciasis can be found in marshes, swamps, rivers and bushlands. Environmental impacts likely to be harmful to building projects in the health care field can, in the main (see section 2.1.1), be generated by topographical, climatic and locational conditions and by fauna-related factors.

2.2.2 Impacts on the environment from the man-made environment

To an increasing extent, adverse effects on health are being caused by
- pollution of ground and surface water,
- soil contamination,
- air pollution and
- biogenic impact paths (build-up of pollutants in plants, animals and the human body).

Some examples that can be cited in support are as follows:

1. Evidence of chemical pollutants in water and food,

2. Increasing stress from air pollutants and smog, particularly in large conurbations but also in rural areas, and the frequent recording of cases of chronic bronchitis and asthma attributable to exposure to smoke and dust. What affects health is, above all, the building infrastructure. The main impacts involved here are ones caused by

- **poor housing conditions,**
- **the non-availability of food, water or fuel, and**
- **lack of facilities for disposing of wastewater and solid waste.**

2.2.3 Impacts on the environment from health care facilities, particularly hospitals

As well as land uptake and ground sealing, it is likely that there will be environmental impacts from impacts on the soil caused by buildings and work done on the terrain, and by the pouring away of liquids and the dumping of solid waste. Surface water may be affected in similar ways. Air pollution can be expected both from the services infrastructure of a health care facility as a result of waste air, combustion processes and solid waste, and it can also be expected from cleaning agents and disinfectants and materials that release vapours harmful to health. Consideration should be also given to indirect impacts and delayed impacts on humans, flora and fauna. These may result from direct contact or may operate via impact paths such as build-up in the soil, infiltration into groundwater abstracted as drinking water, and so on. It should be borne in mind that as the facilities in question increase in size, additional stresses

arise as a result of the traffic generated, such as noise, dust, safety risks and further land uptake.

2.2.4 Protective measures and recommendations

The multiplicity of interactions between modern day health care and the environment make it necessary for protective and corrective measures to be implemented at different levels. Outlined below are measures of this kind for fixing the location of health care facilities and for planning, building and running them.

- **Requirements to be met by the location**

Health care facilities are part of the residential infrastructure and as such should be sited close to dwellings, i.e. in residential settlements. It is advisable for the copiousness of provision to be geared to requirements, with facilities for primary medical care well spread out over large areas. Regional health centres and main and specialist hospitals should then be inserted in this network. One of the things on which the effectiveness of such health facilities will depend is their locational characteristics, among which is whether they are reachable by the population being cared for.

The requirements to be met by the location of a facility result from the purpose for which medical and nursing care is administered. As a rule, locations subject to no immissions or only low levels should be selected. The availability of water of good quality in adequate volumes

must be guaranteed. A reliable energy supply, normally meaning a connection to an electricity supply network, and provisions for emergency backup will be needed, as also will connections to the existing public wastewater drainage system and organised disposal of solid waste. Care must be taken to see that the facility is within reach for emergency medical care. Locations need to be suitable for transport (for linking up with roads and if possible bus and, where appropriate, rail services). The need for supply and disposal infrastructure will very much depend on the nature and scope of the medical care provided. If a dedicated wastewater discharge system has to be provided, as it will in the majority of cases, the wastewater should always be treated first and only then discharged into rivers. Other criteria governing the choice of a location are:

- **land uptake by the planned facility and by the existing or developable facilities at the location,**
- **whether deleterious environmental impacts can be avoided at the location by appropriate building practices, use of buildings, and planting,**
- **zones containing breeding grounds for insects that constitute a health risk should not be selected, or reasonable remedial steps should be taken.**

- **Structural protective and corrective measures**

Buildings for health care facilities need to be developed in the light of medical, hygiene and organisational requirements and should be adapted to climatic conditions at the given location. Environmental impacts may stem as much from the interior of buildings as from the exterior.

Toilets in health care facilities, and the more sophisticated sanitary arrangements in their treatment areas and laboratories, should be designed to meet the requirements of hospital and environmental hygiene. Isolation wards, and primary health care facilities that are called upon to act briefly as isolation stations to avoid any direct or indirect risks, will require additional expenditure on more than the normal scale (to provide dedicated sanitary arrangements, sterilisation units, suitable screening, etc.).

The size, layout, boundaries and use of the grounds, the positions of the buildings and the nature and extent of the plant cover all have a bearing on many of the impacts caused by the environment, such as the action of sunlight and shade, humidity, wind, and dust, though planning, structural and architectural provisions may alleviate such impacts or even, in some cases, make beneficial use of them (e.g. solar energy).

The solid waste and liquids generated by health care facilities, e.g. cleansers, disinfectants, laboratory liquids, pharmaceutical preparations, waste materials from radiotherapy (radioisotopes), need to be classified on the basis of their environmental implications. The problem of disposing of the solid waste and wastewater generated by hospitals and other facilities connected with health care and doing so reliably and in an environmentally acceptable way will generally need to be treated, at the outset, as a problem of special waste. Whether incineration, composting or dumping on rubbish tips is best will depend on local conditions and on the nature of the waste, how it is held before final disposal, and the transport and disposal facilities available. Radiology departments and radiological protection in large hospitals and specialist clinics are always a special case.

The highly infectious waste from hospitals is a particular hazard and one which is aggravated by suitable climatic conditions (heat).

3. Notes on the analysis and evaluation of environmental impacts

The environmental impacts caused by schools providing basic education are generally so slight as not to require any particular analysis. The fundamental prerequisite here is planning that is environmentally aware and gives due consideration to ecological requirements. In the case of sports facilities and schools providing vocational training and education, it is advisable for a separate analysis and evaluation of environmental impacts to be made.

To keep the impacts caused by stresses on the environment down to innocuous levels, it is necessary for reliably maintainable threshold values for pollutant concentrations to be established from sound toxicological and epidemiological evidence and laid down.

Important pointers, often indeed the only pointers, for evaluating the stress on air, water and foodstuffs caused by pollution are provided by the recommendations developed by the World Health Organisation (WHO) which are embodied in its "Health Criteria".

The development and application of country-specific standards is felt to be essential. However, where similar conditions exist in other countries, it may be helpful for experience in dealing

with pollution standards to be compared and contrasted.

The guidelines and statutory codes that apply to German conditions are based on a largely self-contained system of laws and regulations. The main provisions are laid down in the *Bundes-Seuchengesetz* [Federal law on infectious diseases], the *Wasserhaushaltsgesetz* [Federal Water Act] and its supplementary provisions applicable to individual German states, the *Abfallbeseitigungsgesetz* [Waste Avoidance and Waste Management Act], the *Abwasserabgabengesetz* [Waste Water Charges Act], the *Bundesimmissionsschutzgesetz* [Federal Immission Control Act] and *TA-Luft* [Technical Instructions on Air Quality Control]. Another source of information is EC directives.

In Germany, the recommendations and guidelines for building schools and hospitals include specific planning and construction notes that reflect legal requirements and the requirements of the German construction supervisory authorities. For projects in other countries, the existing law will need to be checked for references to the environment. These may provide some points of departure for advice provided by institutional bodies. Studies of typical facilities for providing primary health care and their potential environmental impacts show that simple, environmentally compatible solutions are perfectly feasible, provided that environmental questions relating to planning, execution and operation are considered at an early stage. In the case of large facilities, and particularly hospitals of regional status and hospitals with specialist departments, amplificatory analyses will always be needed to allow environmental impacts as a whole to be evaluated. The wastewater from German hospitals has been classified as medium-

hazardous. Generally speaking, waste disposal from hospitals should be treated as a matter of disposing of special refuse. Another special question is the radiology departments in large hospitals.

However, land and water have a natural self-cleansing ability to deal with certain pathogenic organisms and this will help in allowing simple methods of disposal and treatment to be employed even in tropical and sub-tropical climates. What is crucial though is that there must be no interference with this process of natural degradation and that the process must not create any hazards of its own before it is complete.

4. Interaction with other sectors

The "Schools" sector is linked in a crucial way with questions of schooling provision in regional, urban and rural development programmes.

In urban areas, locational questions relating to schooling facilities in projects such as

- **rehabilitation of urban districts (slums, squatter areas),**
- **sanitation, and**
- **provision of sites and services,**

are likely to be cross-related in significant ways with town planning, development of residential areas and rehabilitation (see also the environmental brief Provision of Housing). It is essential for the present sector to be geared to other infrastructural sectors such as rural and urban water supply and wastewater disposal. Where the appropriate institutional framework exists, close co-ordination is advisable with departments responsible for environmental protection.

Close ties will also need to be established with regional, urban and rural development programmes when facilities for providing primary health care, hospitals, and other facilities connected with the provision of medical care are going to be built. This will affect not only the provision that is made for public health care and the matter of suitable locations in towns, but will also call for interaction with sectors relating to the services infrastructure. More detailed notes on disposal questions will be found in the environmental briefs Analysis, Diagnosis and Testing and Disposal of Hazardous Waste and in Vol. III Compendium of Environmental Standards.

For simple, effective and apposite answers to constructional and technical questions relating to facilities for primary health care, it is advisable to look at what has been learnt in the field of "appropriate technologies".

5. Summary assessment of environmental relevance

In the present sector, environmental implications can be obtained in a form in which they are comparable by

- adopting the same division as is applied to the provision itself, namely primary provision, provision of main centres, and provision of special units and considering the environmental implications of each of these, and
- by adopting location-related criteria.

The improvement of schooling and health care is often felt to be a sine qua non for encouraging general development processes tending to produce better conditions of life.

Whereas schooling facilities generally exert easily assessed and only slight impacts on the environment, the sports facilities associated with schools, and schools with special laboratory facilities, particularly schools giving vocational training, require closer scrutiny for any possible environment impacts. In the present sector, there will not normally be any need to develop requirements for environmental protection which are not already embodied in the sector's own rules for environmental design.

In the case of hospitals and other facilities assignable to the field of health care, there will always need to be a separate investigation into any possible adverse environmental impacts caused by risks of infection.

Planning approaches that are particularly geared to environmental requirements but cost-

conscious at the same time are feasible for projects of both kinds.

The locations of the facilities will be determined by planning objectives such as a wide measure of freedom from immissions, a good microclimate, and easy access. The environmental impact of the facilities on the location and its environs should be looked at.

Simply because of its underlying assumptions, the health care sector has major implications for the environment. The relevance to the environment of steps taken in this area lies mainly in the indirect and consequential impacts of these steps. In the light of their possible "negative or positive feedback", it seems all the more important for such impacts to be studied and for attention to be focussed on the subsequent action that can be taken in response to them.

With projects of both types, consideration needs to be given both to general interactions with other sectors and to interactions which need to be looked at from a variety of points of view. Full advantage should be made of any opportunities to adopt a unified approach.

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10. Urban water supply

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1. Scope

What is meant by urban water supply is facilities for meeting the water requirements of an urban population, of the public sector, and of trade and industry. The distribution of the water may take place via either distribution systems (piped supply) or non-piped supply points (e.g. wells).

In many countries the term "urban" is not necessarily related to the size of the community in question and for that reason the type of supply is defined as follows

	Type of supply	Consumption in litres per inhabitant	

		per day (l/i/d)	
1)	Non-piped supply		15 - 40 l/i/d
2)	Piped supply from stand pipes	up to	40 l/i/d
3)	Piped supply from yard taps	up to	60 l/i/d
4)	Piped supply from house taps	more than	60 l/i/d
5)	Piped supply to special customers such as trade, industry, public sector	varies widely	

In the context of development efforts, consumers in groups 2) and 3) above should be accorded priority treatment, as also should consumer group 1) where there are plans for them to be connected to the piped supply. To the figures in the overview table must be added allowances, considerable in some cases, for wastage and for the water losses that affect the

majority of existing piped supplies. The figures considered for sizing the component parts of an urban water supply system should be peak demand figures (e.g. at the day and hour of maximum demand). In many countries, it is only seldom that allowances for water supplied for fire-fighting (the peak measured demand) will enter into the calculations.

Water abstraction breaks down into the following sub-divisions:

- abstraction from groundwater sources,
- abstraction from surface water sources.

Hybrid forms of abstraction should also be allowed for:

- abstraction via bank river intakes using infiltration drains
- artificial infiltration with recovery.

The following are the component parts of the urban water supply layout:

- abstraction (wells, infiltration galleries, spring tappings, abstraction structures, storage basins/reservoirs)
- treatment (e.g. iron removal, chlorination, desalination)
- storage of the treated water
- distribution system (pipe network, long-distance supply facilities).

In the case of artificial infiltration with recovery, this layout has inserted into it at the upstream end the

- infiltration system (basins, recharge wells, drain ducts).

2. Environmental impacts and protective measures

2.1 Overview

What should be considered in connection with urban water supply are the environmental impacts both on the volume of water available and on the quality of the water.

In many countries, and particularly in zones of varying climate, the problem of water availability is beginning to take precedence over the problem of water quality.

As with the parts of the urban water supply system, impacts can be broken down into the following groups:

- **impacts from water abstraction**
- **impacts from conveyance and treatment of raw water**
- **impacts from piped distribution.**

In addition to the above, there are also secondary impacts in the form of

- consequential effects of an urban water supply system.

2.2 Impacts from water abstraction

2.2.1 Groundwater

The abstraction of groundwater will cause a change in the aquifer water balance and there are a large number of consequential effects that this may have. The balance is between

- inflow-side components (groundwater recharging from precipitation and surface water, subsurface inflow from adjoining aquifers, artificial infiltration) and
- outflow-side components (outflow to surface water, drains, abstraction intakes, etc.).

It is essential to remember that, due to hydraulic interaction, the changes caused by water abstraction in components on both sides of the equation may even be lasting ones (e.g. an increase in the inflow from adjoining aquifers).

Thought must also be given to the interaction between availability and use and between groundwater and surface water. Greater use of surface water may cause a reduction in infiltration into the subsoil, and the remaining volume of surface water may be more heavily

polluted in particular ways. The consequence may be an increasing requirement for groundwater use (2.2.2).

The environmental impacts that a change in the components contributing to the balance may have are:

a) Quantitative depletion of groundwater resources

Increasing quantitative depletion of groundwater resources results from:

- **increasing consumption of drinking water due to a growing population and an improvement in the standard of the supply**
- **more rearing of livestock**
- **increasing demand for industrial water (for trade and industry)**
- **wasting of water**
- **water losses from defective distribution systems.**

Other factors that need to be taken into account are ones that lead to a temporary or permanent reduction in groundwater resources, such as declines in precipitation in aquifer watersheds (due to deforestation, steppification). It should also be borne in mind that, under the traditional urban water supply strategy, it is peak demand that has to be met, but that this demand often occurs in the dry season. The high consumption during dry periods and the vast water losses from some piped systems, only a proportion of which is returned to the

groundwater, then give rise (seasonally) to a particularly severe depletion of groundwater resources.

b) Long-term changes in groundwater quality

These may be caused by:

- mobilisation (leaching out) and subsequent spread of previously immobile pollutants
- increases in flow velocity (e.g. in natural gypsum beds or man-made pollutant deposits)
- changes in groundwater flow (resulting in interception of charges that previously flowed harmlessly away, inducement of infiltration from contaminated surface waters)
- inducement of widespread infiltration from overlying or underlying groundwater storeys in which groundwater quality is poorer.
- entry of pollutants due to the use of fertilizers and pesticides
- intrusion of salt water into aquifers close to coasts
- deterioration in groundwater quality caused by seepage of untreated waste water from open, unsealed roadside ditches, leaking sewers or poorly built cesspits, or by seepage of pollutants and toxins from liquid industrial and commercial waste.
- charging with minerals from irrigated areas, caused by the high evaporation in arid and semi-arid areas and subsequent entry into the groundwater as a result of

periodic mobilisation.

- leakage of pollutants from storage depots and transport systems for liquid and mineral products.

c) Localised and extensive lowering of the water table

In the case of groundwater abstraction, lowering of the water table is inevitable for hydraulic reasons. However, the size and physical distribution of the lowering will depend on local conditions, e.g. the positions of the wells, the structure and nature of the aquifer, recharge conditions. Typical consequential impacts of water table lowering are:

- drying up of ecologically important wetlands,
- reduction in soil moisture content (field capacity), with plant- specific impacts on plant cover (change in the natural and cultivated flora, e.g. steppification) and with consequential effects on the fauna,
- total depletion of groundwater resources during sustained dry spells (drying up of wells),
- drying up of springs and watercourses,
- soil settlement.

The environmental impacts of water table lowering are usually less severe where there was a low water table (> 10 m) even before abstraction.

Environmental protection measures to minimise the harmful effects of groundwater collection will be concerned mainly with selection of suitable locations for wells and the design and modes of operation of the wells. The adverse impacts of excessive abstraction of groundwater may also be mitigated or prevented by efficient use of water, by seasonal control of water consumption (rainy season vs. dry season) and by introducing and operating systems of consumption-dependent tariffs and charges.

To boost the efficiency of environmental protection measures in dealing with the impacts of groundwater abstraction, it will be necessary not only to carry out the appropriate hydrogeological reconnaissances and to assess the total water balance (groundwater and surface water), but also to provide continuously operating measuring and monitoring facilities, the purpose of which will be:

- to ensure an ongoing improvement in evaluations of and statements on questions of hygiene and hydrogeology,
- to watch for changes in the groundwater supplies (volume and quality) by constantly checking groundwater levels, groundwater quality and volumes of groundwater abstracted,
- to keep a constant watch for waste of water of all kinds and for water losses from piped urban water supplies, by means of continuously operating measuring facilities (district water consumption, consumption from stand pipes and domestic connections), and to take action to counter both of these (by repairing damage in good time, by tariff setting and by penalising the wasting of water),

- to apply restrictions on the water allocation to other, competing user groups in order to ensure that a supply is available for human beings (emergency supply),
- to put in hand rehabilitation work on existing parts of the urban water supply system (to replace defective water mains and domestic service pipes, faulty taps and cocks, and overflowing cisterns and domestic storage tanks),
- to monitor the efficient execution of rehabilitation work by checking the results.

2.2.2 Surface water

The use of surface water will cause a change in the water balance and this, as in the case of groundwater abstraction, may have a wide range of consequential impacts. What will need to be considered in this case are two-way effects between surface water and groundwater availability and use. Also of importance are the following factors:

- In some regions, more surface water may become available in the future, due for example to changes in the (micro)climate (such as an increase in precipitation due to the effect of artificially created reservoirs), to an increase in surface runoff caused by changes in the vegetation in the surface water catchment area (deforestation), to building over (roads, buildings) producing greater surface runoff, or even to the discharge of (cleaned) wastewater from towns and smaller communities into the surface water.
- In other regions, a climate-related decline in precipitation may occur, and in this way surface water runoff may be reduced and the quality of the water degraded, in

which case the situation will be even worse in countries where surface water is not available throughout the year anyway.

- Increasing abstractions from flowing waters (by means of river intakes) will cause a reduction in the availability of water in many regions, particularly at periods of low water, and in the self-cleaning action of the body of water and in infiltration into the subsoil.

- If demand for water increases and the quantity available in flowing or dormant surface waters is reduced and at the same time the quality of the water is degraded, a requirement often arises for water to be brought into the region in need from remote areas or for the demand for water to be met from more plentiful or less plentiful groundwater resources. In particular borderline cases, emergency situations may arise, i.e. where supply of even the minimum amount of water required for the human population can be guaranteed only at high cost.

a) Quantitative depletion of surface water resources

The demand-side components listed in 2.2.1 are likely to cause an increase in the use of surface water. Account should also be taken of climatic changes and changes in the vegetative cover in the watershed, as these may result in some regions in reductions in the amount of surface water available or in an adverse time-related runoff distribution (greater runoff at periods of high water with a higher charge of suspended matter and sediment, but lower runoff at periods of low water).

What is often lacking for checking the volume of runoff, the extent of the resources and the volumes abstracted is an adequate network of measuring stations within the watersheds (for precipitation) and at particular points on the bodies of water (for level), and expert staff to analyse the measurements and monitor the multi-sectoral use of surface water resources and to draw up water balance sheets (for ground and surface water) and water management plans.

b) Changes to ecosystems caused by water abstraction

Relatively large reductions in flow, particularly at times of low water, may have impacts on all the ecological processes in a body of water or watercourse and on its shores or banks. Biotopes of value to the landscape or ecology may be adversely affected or even totally destroyed; under certain circumstances the ecological equilibrium, with its balanced variety of floral and faunal species, may be altered. However, such impacts only occur when the abstraction of water, measured against the total flow, is substantial, i.e. such that an ecosystem no longer receives its minimum water requirement. Also, the impacts of water abstraction are, as a rule, not spread over a wide area but (depending on the topographical situation) confined to small areas (strips along banks and shores, floodplain meadows).

c) Intrusion into the water supply of unknown or undetected hazardous constituents

The use of surface water to provide a water supply is fundamentally a problem of water quality. In properly designed treatment plants, suitable monitoring facilities ensure that safe

feed into the distribution system is possible. However, a risk of damage to health and impacts on hygiene may occur if pollutants remain undetected in the water, the pollutants being for example the result of uncontrolled discharge of substances into the water. The pollution may possibly take the form of a concentrated dose of a discharge which at other times is continuous and relatively harmless (e.g. when toxic pollutants are being drained off). Another risk is that, due to their low detectability, constituents may evade the existing monitoring and testing facilities. Substances that are difficult to detect in this way include a range of industrial solvents that are considered to be carcinogenic even at extremely low concentrations if continuously ingested by humans. Where there is a risk of exposure to such pollutants, the requirements to be met in water-protection zones must be particularly stringent, as also must the checks made in the zones, and provision must also be made for sensitive early-warning measuring devices to be introduced in stages and for embargoes on abstraction to be applied.

In the event of surface water abstraction, the following protective measures need to be borne in mind:

- the introduction of suitable measuring and monitoring systems to keep a watch on water levels, runoff volumes, charges of sediment, sand and suspended matter, chemical, physical and biological water quality, and pollutant charges, and also to monitor an extremely wide diversity of parameters applicable to ecosystems in the watersheds,
- collection and analysis of the data acquired by the measuring and monitoring systems, and preparation of hydrogeological appraisals,

- collection and analysis of hydrogeological data, including continuous measurements made at observation and producing wells in regions where use is made of both groundwater and surface water resources, with the object of producing water budgets to show the volumes of water available for use and of checking that distribution conditions are being complied with.

- monitoring of water quality and of the self-cleansing action of surface waters,

- analysis of data to allow the introduction in good time of protective regulations, statutory provisions to safeguard resources, and conditions governing supply in emergencies,

- appraisal of existing uses of surface water, for the purpose of preventing harm to persons further downstream as a result of fresh abstractions of surface water and/or the discharge of used water,

- the prevention of waste of water, the introduction of restrictions on water allocated, and the execution of rehabilitation work on the drinking water distribution system (see section 2.2.1 on Groundwater).

2.3 Conveyance and treatment of raw water

When raw water is conveyed in open channels, and particularly when it is withdrawn from contaminated or hygienically unsatisfactory surface waters, it can be expected that health problems will arise as a result of illicit use of the raw, contaminated water and of human beings coming into contact with it in other ways.

In the course of treatment of raw water, adverse environmental impacts may arise due to incorrect plant operation (inattentiveness by operating staff, absence of alarm devices) or as a result of, for example, the disposal of sludge from settling basins, of filter cakes, and of chemicals from stocks held (e.g. disposal of old stock), excessively high doses of chemicals (e.g. chlorine), and the disposal of alkali concentrates used in desalination processes.

Factors of significance in connection with the treatment of raw water are therefore the efficiency of the treatment process, the operation of the monitoring and alarm facilities, and the possibility of gearing treatment to the seasonal variation in the quality of the raw water. Another factor that has an important bearing on the possibility of achieving proper treatment of the water (meaning the pumping and pretreatment of the raw water, metering in of chemicals, flocculation, filtering and disinfection, and analysis) and on the possibility of guaranteeing hygiene in treatment plants is the standard of training of the staff employed in such plants.

Environmental protection measures that may be envisaged are as follows:

- measures to prevent access to systems conveying raw water for the purpose of extracting water for use (as drinking water) by humans, and/or warning the population of the dangers of using contaminated water,
- codes governing the quality of the discharge from treatment plants, with due consideration for the seasonal capacity of receiving waters and the rights of use and expected requirements of persons further downstream,

- installation or retrofitting of environmental protection facilities in water treatment plants, such as detention basins, sprinkler systems for chlorine stations, secure storage for fuels and chemicals.
- installation of measuring and monitoring facilities for monitoring water flowrates and quality and for reporting incidents in the course of water treatment (e.g. damage to a tank of chlorine gas).

2.4 Piped distribution

Where the environmental relevance of distribution lies is in the following impacts:

a) Due to the poor technical standard of the urban water supply system in many countries and particularly the poor technical standard of the distribution pipes (inferior materials and bad laying as a result of mistaken low-cost policies), the incidence of defects is very high in buried pipes. In industrialised countries, the average incidence is 0.2 to 0.3 defects per km per year, whereas in other countries figures of up to 9.1 defects per km per year have been found.

Water losses from dilapidated distribution pipes are often many times greater than consumption.

b) Simply due to high water losses, it is often the case that the capacity of urban water supply plants is exceeded well before they achieve their designed output to consumers. It then becomes impossible to maintain a 24 hour supply and an intermittent supply is introduced.

c) When the supply is interrupted at times (intermittent urban water supply), the consequent lack of outward pressure allows contaminated water to makes its way into the distribution network through fractures in buried pipes, the contaminated water coming for example from ditches carrying wastewater, leaking roadside channels carrying wastewater, leaking sewage pipes, defective/overflowing settlement basins, badly designed dumps for waste and toxic materials, etc. This constitutes a risk to the state of health of the population.

d) Water may become foul due to stagnation in runs of pipe where the hydrodynamics of the system are poor or in clean-water tanks in the distribution system through which there is insufficient flow.

e) Contamination of the water in dilapidated distribution systems is often so bad that the water, despite being heavily disinfected (e.g. by high chlorine dosage rates) at the input to the distribution network, becomes so contaminated with organic matter on its way from the input to the consumer that there is a permanent health risk.

The following are suitable measures which can be applied to minimise the impacts of piped distribution:

> **- critical assessment of the techniques for reducing water losses developed in industrialised countries and adaptation of these techniques to meet the particular circumstances in the country and the special requirements that exist (e.g. use of leak detectors on pipes where the pressure is low, quantitative determination of water**

losses from intermittent water supplies, execution of measurements by district metering to determine water losses in distribution districts only sparsely equipped with gate valves and hydrants).

- introduction of appropriate measuring and monitoring systems and pipe network improvements (e.g. installation of essential gate valves) to allow a constant watch to be kept on water consumption, water waste, illegal extraction of water, and water losses by monitoring the supply being fed to distribution districts and the pressure within the districts and to check the effectiveness of improvements to the pipe network (reductions in water losses, etc.).

- monitoring of the incidence of defects in the distribution districts in the urban water supply system.

- establishment of priorities for the permanent upgrading of the distribution system in the urban water supply system (early detection and repair of defects and rehabilitation or replacement of sections of the pipe network where there is evidence of a high incidence of defects etc.).

- improvement of the standard of materials used and the standard of the laying work in the distribution system.

- introduction of a continuous water supply (meaning adequate 24-hour pressure in the pipe network) once the distribution system has been upgraded.

- monitoring of the bacteriological quality of the water (e.g. for excess chlorine) at the consumer connections/stand pipes.

2.5 Consequential impacts of urban water supply projects

The purpose of an urban water supply system is to distribute reasonable quantities of water of a satisfactory hygienic standard to consumers. Using good drinking water eliminates the health risks that occur because the water being drunk is unhygienic. However, any rise in water consumption also means an increase in wastewater arisings and thus, in the absence of appropriate provisions for disposal, a greater potential danger to health posed by an increase in water-borne diseases.

In the current state of the art, 100% of the water from an urban water supply system is produced to good drinking water quality standards, whereas in fact only 5 to 15% of the water needs to be of drinking water quality. It is therefore on cost grounds as well that it is important to make sparing use of drinking water. By introducing suitable (consumption-related, cost-covering) tariffs and possibly even by having separate distribution networks for drinking and other water it will be possible to achieve sparing, efficient use of hygienically acceptable water.

A special problem is posed by the unhygienic treatment of the water as it is being transported from stand pipe to user and its unhygienic storage in homes, and/or by defective domestic installations (e.g. defective roof tanks) that pose a permanent threat of disease.

Adverse consequential impacts of urban water supply projects arise mainly as a result of errors and shortcomings, such as:

- shortcomings in the quality of the materials used and in the standard of work done,
- shortcomings in operation, maintenance and rehabilitation,
- overrunning of the designed capacity of the urban water supply system as a result of waste and losses of water,
- shortcomings in the instruction given to the population and particularly to women, who often bear responsibility for hygiene-related matters such as transporting water, storing water in the home, cleaning, and the preparation of food.

A frequent source of dissatisfaction among consumers is a decline in the standard of the supply caused by defects. Grievances of this kind then lead to increasing unwillingness to pay bills and hence to a falloff in income from the sale of water and, what is more, to such things as lack of interest in motivating and instructional campaigns (to involve the population, to promote efficient use of water and to provide education in hygiene and health).

There are special demands that the planning and execution of maintenance and rehabilitation measures, based on the collection and analysis of data and information, must be expected to meet. This applies particularly to non-visible parts of the water supply system such as buried pipes. Serious mistakes are often made here, such as replacing old pipes (i.e. ones more than 50 years old) when the incidence of defects in old pipes of this kind is often lower than in pipes laid in the past 20 years.

In many cases new water abstraction and treatment works are built before dilapidated

drinking water distribution networks have been upgraded.

One basic consideration that should be borne in mind is that the consequential impact of a proper urban water supply system will be beneficial to the state of health of the population when it is not simply waste water disposal but solid waste disposal, housing conditions, and food hygiene etc. too that are improved with the aim of producing a permanent effect on the state of health and living conditions of the population. The following aspects also deserve special attention in this connection:

- **changing the population's traditional attitudes to the scarcity and importance of water as a resource (water is not a "free" commodity),**
- **enlightening and involving target groups, and particularly women, with respect to the costs and value of a proper urban water supply system and improved sanitary conditions and what they can expect from them.**

To minimise the consequential effects of projects in the field of urban water supply, all the facilities should be planned, constructed, operated and maintained to a standard appropriate to local conditions and in line with the current state of the art. There must be a guarantee that the operation of water supply systems (for water abstraction and distribution) can be maintained for the full 24 hours in order to prevent any contamination of the water being distributed. It must be ensured that the water distributed is used sparingly, either by introducing and making active use of metering and monitoring facilities and/or by bringing into force appropriate tariffs and charges commensurate with the sparing use of water.

At the same time, provisions for waste water disposal and other sanitary provisions will also need to be made.

By the proper maintenance and rehabilitation of existing water supply facilities, and particularly of buried water pipes with their known susceptibility to defects, it will be possible both to reduce water losses and to prevent consumer dissatisfaction (caused by disruptions to the supply resulting from frequent repair work and by an intermittent supply) plus any related drop in income from charges for water.

Other essential prerequisites for preventing adverse consequential impacts are as follows:

- the introduction of measuring and monitoring systems for logging flowrate and pressure parameters and for the early detection of defects in water supply systems (distribution networks),
- the introduction of measuring and monitoring systems for monitoring the quality of the drinking water being distributed,
- the involvement of the population, and particularly women, in a very wide variety of watchkeeping tasks such as reporting defects (leaks) and water waste, and the giving of instruction in good hygienic use of water (containers for carrying water, the carrying itself, and storage of water in the home),
- the systematic introduction of improvements in systems which are to be integrated into new systems in the future,
- the introduction of efficient operating and maintenance systems,

- the planning of expansions from a practical point of view,
- the avoidance of past errors and of the uncritical acceptance of techniques from industrialised countries.

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3. Notes on the analysis and evaluation of environmental impacts

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3.1 Limits and guidelines in Germany and other industrialised countries

Existing quality standards in the Federal Republic of Germany, in the member states of the European Community (EC) and in other industrialised countries are mainly focussed on the question of supply with satisfactory drinking water. In the main, these standards lay down limits or guideline or maximum values for constituent concentrations and bacterial counts which must be observed for certain uses in order to rule out risks to the health of humans. Consequently, the environmental relevance of these standards lies chiefly in their aim of preventing repercussions on health and hygiene from an unsatisfactory supply.

In the Federal Republic of Germany, drinking water supply is governed by the standards and guideline values in the Trinkwasser-Verordnung (TVO - drinking water regulations), but these cover only the most important types of substances (of the 650 or more that have so far been classified as hazardous to water). In addition to this, there are generally sectoral codes in the Federal Republic of Germany for assessing and, where applicable, preventing impacts generated by water supply on environmental resources. For historical reasons, the Republic has a federal structure and because of this structure it is possible that the implementing regulations in particular may be different in different federal states. For this reason alone, there may be major problems in transferring standards to other countries.

The most important sectoral statutory instruments are concerned with water management (the "*Wasserhaushaltsgesetz*" (Federal Water Act) and the water laws of the individual federal states), and nature conservation and care of the landscape (*Landespflege und Naturschutzgesetze*). However, the sectoral division means that other statutory instruments, such as mining law, may also have an indirect bearing on the question of limiting environmental impacts generated by water supply.

The most important guidelines relating to the setting up of supply wells are concerned with the laying down of so-called water protection areas.

The areas are divided into three hazard zones and in them restrictions on use are laid down. The aims of these restrictions are as follows:

(1) to prevent pollutants from entering the soil and groundwater in the vicinity of wells.

(2) to ensure that pollutants are properly degraded as they pass through the soil and are carried into the groundwater (the 50-day line).

(3) to ensure that if accidents occur outside the protection zones, enough time is available for countermeasures to be implemented.

The implementing provisions that apply in the Federal Republic of Germany (e.g. DIN standards) help to ensure that, for example, there is no uncontrolled entry of pollutants into the groundwater when wells are being sunk and, by providing authoritative directions for assessment and analysis, that decisions likely to create environmental stress are not made later on.

Guidelines and standards from other industrialised countries are, on the whole, intended to achieve similar objectives to those in the Federal Republic of Germany.

However, depending on the intensity of use and the historical background, laws and regulations in given countries may be very different, especially with regard to the precise values laid down and the number of quality requirements specified for drinking water. In the EC, there have already been some initial successes in harmonising the drinking water standards of the member states.

3.2 Other national guidelines

Specific laws and guidelines applicable to the environmental impacts of water supply are as yet unknown in many countries.

In some regions there are traditional codes relating to the abstraction and distribution of water that govern matters such as:

- **the use of water from springs,**
- **the limits set for the withdrawal of water from wells and well fields,**
- **recharging of groundwater**
- **use of suitable wastewater for irrigation,**
- **management of the water from impoundments,**
- **distribution of surface water for irrigation,**

These may very well be important for environmental protection and an endeavour should be made to take them into account on appropriate projects.

However, it should be remembered that there is often only an inadequate foundation for:

- **water budgets,**
- **forecasts of multi-sectoral water requirements,**
- **forecasts of future water quality,**

- priority needed to be given to the allocation of water resources for human use,
- statutory water regulations,

due to a lack of basic data.

Internationally, it is chiefly the World Health Organisation (WHO) International Standards for Drinking Water that serve as a main reference tool. However, it should be remembered when carrying out projects in countries where conditions are extreme that the WHO standards are only recommendations and that exceptions may be allowed in cases where there are good grounds for doing so. Over past years greater importance has been attached to the WHO's minimum hygiene requirements (bacterial counts, pathogens) than to the maximum concentrations of water constituents.

It is often the case that, although broad guidelines and regulations may already have been laid down at national level, there are no mechanisms or resources for implementing them.

3.3 Rating of environmental impacts

For rating environmental impacts, there are different priorities that may be adopted at the outset. In countries where there is already a scarcity of water resources, overriding priority may be given to assessing how much water will be available in the medium and long term. Where water resources are adequate in terms of quantity, then priority in evaluating the environmental impacts of urban water supply will be given to the hygiene and compatibility

with good health of the water distributed for human consumption, bearing in mind that if the resource is not adequately safeguarded for the future or is not adequately protected, this may jeopardise the urban water supply's long-term benefit to those supplied.

A very negative view should be taken of uncontrolled and wasteful use of water, e.g. where, in an arid region, the private growing of wheat by irrigation is allowed to take precedence over long-term use of scarce groundwater resources for general human consumption.

2.6 Environmental protection measures and recommended options.

Area/problems and traditional measures	Recommended options
1. Technicalities of urban water supplyAdoption of standards from industrialised countries, modification of standards for reasons of cost, lack of resources to finance higher subsequent costs in the area of operation & maintenance (O&M), problems caused by low-cost policies	- Changes in grades of materials with the aim of improving quality - Temporary increase in O&M expenditure - Auditing of results - Adjustment of O&M expenditure - Inclusion of O&M costs in the financing of the project

2. Introduction of water quality standards, of statutory provisions for protection areas, of bylaws, and of laws and codes Adoption of standards from industrialised countries or international recommendations, where there are no national requirements	- Start with minimum requirements that can be achieved without any changes in legislation. - Decide on the steps towards more comprehensive requirements on the basis of local priorities - Bring in local specialists and legal experts
3. Groundwater abstraction	- Introduction of permanent measuring facilities to monitor groundwater levels and volumes abstracted - Introduction of permanent metering facilities to monitor consumption (district metering) in the distribution network - Legal codes to lay down different per capita consumption levels (rainy season/dry season)

	- Introduction of different, cost-covering tariffs for rainy season and dry season
4. Surface water abstraction and water treatment plants - as for 3. Groundwater abstraction, amended as appropriate -	
5. Water abstraction and traditional measures High water losses caused by defective pipes due to mistaken low cost policies, hence severe depletion of the resource and an adverse effect on health,	- Systematic defect logging and analysis - Application of new methods of assessing water losses - Replacement of vulnerable sections of piping network from defect analysis findings (demonstrable requirement) - Installation of permanent metering facilities (for flow rate and pressure) to monitor consumption and losses and to track down defects - Early detection of defects by

particularly where supply is made intermittent, problems solved by constructing new water abstraction facilities, pipes replaced on the basis of age, sporadic leak detection covering the entire distribution network and/or introduction of intermittent distribution	means of the metering facilities and repair of the defects in good time - Improvement of the overall standard of the network (installation of essential stop valves) - Drawing up of plans of existing network on the basis of priorities - Motivation of women and children to report defective supply facilities (defective stand pipes, overflowing house tanks, defects in supply pipes)
	- Introduction of metering and monitoring facilities in the districts of the urban water supply system - Improvements to system for metering domestic water

6. Covering water demand from the urban water supply Increased water demand due to - increased consumption - high water losses - waste of water - illegal withdrawal Solution to problem attempted by constructing new water abstraction facilities, setting up of stand pipes rather than connections serving individual homes and/or introduction of intermittent supply.	supplies - Systematic introduction of metering of domestic and stand pipe supplies - Improvement of system for releasing air from pipe network - Introduction of consumption-reducing taps, etc. - Reduction of water losses as detailed in 5. - Introduction of (per capita) consumption level standards for rainy and dry seasons as detailed in 3. - Monitoring of restrictions on consumption in dry season and results of action to cut water losses - Introduction of cost-covering tariffs and improvements to payment collection system - Involvement of population

	(women) in a wide range of watch-keeping functions

4. Interaction with other sectors

Projects in the urban water supply sector have a multiplicity of interactions with other sectors; the most important of these occur where there are:

a) competing uses for the water resource (urban water supply, irrigation, consumption by trade and industry, power generation) or other stress-creating demands on it,

b) activities that may pose a threat of pollution to the water resource (use of fertilisers and pesticides, incorrect storage of refuse and trade and industry waste, pollutant-charged precipitation caused by emissions, non-secure transport of pollutants),

c) plans, and their physical results, that make it necessary for the waste water disposal system to be improved,

d) planning that causes interference with groundwater recharge (impoundment or diversion of surface waters, changes to vegetation, drainage operations, building).

Table 1 is an overview of the sectors that interact with urban water supply and contains

cross-references to other environmental briefs that are of crucial importance for evaluating consequential impacts.

The urban water supply system is a essential part of any overall town-planning scheme. The best opportunity for avoiding consequential environmental impacts therefore lies in balanced planning for urban development with due consideration for regional planning and for water framework planning. This is particularly true of the interactions between urban water supply and water disposal and the rule that should be followed in practice is that supply with drinking water and discharge of waste water should be planned together to rule out the possibility of overloading. It is only in the last few years that the later consequences of incorrect waste disposal, and particularly the disposal of industrial waste, to urban water supplies have been realised in the industrialised countries. Given the industrial development that is going on in many countries, it is clear that consideration also needs to be given to choice of location and waste water disposal when urban water supply projects are in prospect.

***Table 1* - Environmental impacts from related sectors**

Sectors where interaction exists	Nature of intensified or added impacts	Environmental briefs to be studied
		Rural Water Supply Briefs relating to

Water abstraction for other purposes - supply of water for agriculture - supply of water to industry	*greater resource depletion and water table lowering *adverse effects on other users *reduction of quality	agriculture Large-scale Hydraulic Engineering Rural Hydraulic Engineering River and Canal Engineering
Hydraulic engineering activities - Construction of storage reservoirs - River engineering, river straightening	* ecological and sociocultural changes * sociocultural changes * water pollution * long-term threat to groundwater caused by pollutant incursions from waste storage and leaks and by agricultural activities, including nitrate incursions into groundwater and pesticide/feed incursions into reservoirs	Provision and Rehabilitation of Housing Specific briefs in the "Trade and Industry" field, e.g. Sugar, Pulp and Paper Petroleum and Natural Gas Wastewater Disposal Planning of Locations

	* overloading of the infrastructure all its consequential impacts * reduction in groundwater replenishment * greater surface runoff	Solid Waste Disposal Structural and Regional Planning Water Framework Planning

5. Summary assessment of environmental relevance

Generally speaking, it will not be possible to assess the severity of the impacts created by urban water supply systems by following a standard, fixed procedure and it will be more a matter of weighing the good intention of developing a life-preserving resource against the related consequences of interfering with the ecological equilibrium that will follow under the laws of nature. Those responsible for the project also need to be aware of the fact that drinking water performs the role of a pacemaker, in the widest sense of the word, for sociocultural and socioeconomic conditions and care therefore needs to be exercised in bringing it into play as a contributory factor to structural improvement.

An assessment of the environmental relevance of urban water supply can be undertaken by considering the following questions:

- **the appraised water resources, and multi-sectoral use,**
- **evidence for efficient water use in present and planned urban water supply systems combined with efficient disposal,**
- **planning considerations of significance for environment-orientated urban water supply projects.**

5.1 Appraised water resources, and multi-sectoral use

- **Evaluation of the current availability and quality of water resources in the light of multi-sectoral use and seasonal variations in availability, quality and use.**
- **Reliable appraisal of the future availability and quality of water resources and reliable monitoring of their present availability and quality (constant measurement, hydrogeological, hydrological, chemical, physical and biological checks, and professional analyses and appraisals).**

5.2 Evidence for efficient water use in existing or planned urban water supply systems coupled with efficient disposal

- **Constant monitoring of the use of water resources by the body operating the urban water supply system in collaboration with other water resource users.**

- Consumption monitoring, control of consumption (during dry periods), monitoring of water losses, and quality monitoring of the water supplied from the urban water supply system.
- Evidence of the need for rehabilitation work to be done on the urban water supply system, and particularly on the water distribution system, classified by priority.
- Efficient implementation of statutory codes and regulations,
- Efficient disposal and disposal monitoring,
- Effective provisions for improving the availability of water resources by means of artificial infiltration, retention basins, dams.
- Efficient re-use of cleaned water.

5.3 Curative measures for inefficient water use in existing urban water supply schemes and inefficient disposal

Curative measures may need to be applied to one or more of the items listed in 5.2

5.4 Important planning considerations for environment-orientated urban water supply projects

There is no fundamental reason why urban water supply systems should not be planned and constructed in an environment-orientated way. However, for this to be the case, there are a number of preconditions that have to be met which, in particular cases, may sometimes entail severe restrictions on water consumption.

The planning of environment-orientated urban water supply projects will call for:

- the environmental impacts of planned urban water supply systems to be checked for improvements, amendments and extensions likely to affect the acceptability of a project and the considered need for and benefits from it, against the background of country-specific value systems. (Simple unquestioning adoption of standards from the industrialised countries may lead to major planning errors.)
- an attitude of problem-awareness directed to regional conditions to be created among project planners and population in connection with the environmental implications of water consumption. (Policies restrictive of consumption in areas short of water and areas at risk ecologically, the importance of introducing cost-covering tariffs, the implementation of statutory codes and regulations).
- careful on-site investigation of conditions, such as what the requirement is, water availability and quality, the regenerative capacity of the resource, the risk of pollutant intrusion, and impacts of water abstraction on the ecology, with the services of specialist multi-disciplinary bodies being called upon to deal with particularly involved questions (depletion of water resources, consequences of water table lowering).

These on-site investigations must also cover the condition of existing systems and an assessment of existing shortcomings and obvious errors in the techniques employed likely to have repercussions on the improvement of the existing systems and practices.

The local investigations should pay particular attention to socio-economic questions, such as family income, income of women, stress on women caused by transporting water, attitude of the population to the scarcity and importance of water as a resource, willingness to pay, and other questions such as the willingness of the population to assist in keeping a watch on the efficient use and distribution of water and to play some part in repair work.

- assistance with the setting up of indigenous monitoring bodies to ensure that the requisite environmental precautions specific to the project are taken.

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11. Rural water supply

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1. Scope

The term "rural water supply" covers all the measures taken to satisfy the demand for water in predominantly rural regions.

Rural regions of this kind may be typified by

- **nomadic ways of life,**
- **peasant ways of life,**
- **peri-urban ways of life.** [1)]

1) This does not include plantations and large-scale agricultural undertakings.

Rural water supply embraces the supply of drinking and household water to the rural population plus supply of the water required for purposes such as garden watering. However, though this constitutes an environmental problem in its own right, rural water supply also includes the watering of livestock plus the supply of water for livestock watering, because in rural areas it is virtually impossible in practice to draw any clear distinction between drinking water for humans and drinking water for livestock.

The supply of water for general agricultural purposes does not come within the scope of rural water supply; in particular, rural water supply does not cover systems for the irrigation of fields or rural hydraulic engineering works. In contrast to urban water supply systems, there is no piped distribution in the majority of rural water supply systems. Exceptions to this rule are the supply pipes and the (generally quite short) runs of pipe that in deprived areas form the rudimentary networks supplying public stand-pipe systems in spread-out villages.

Water demand must, inevitably, adjust itself to the supply that is present and usable. Where it is simply a matter of supplying the rural population, demand is generally between 15 and 30 l per person per day (l/p/d) and sometimes even less, and it seldom rises to levels of more than 60 l/p/d (only where there are house and yard connections). To cover the demand for water for livestock, an additional 15 l/d will be needed for each small animal unit and around 75 l/d for each large animal unit.

Depending on the nature of the abstraction, rural water supply can be divided into the following types:

- water supply from groundwater
- water supply from surface water based on

- **use of surface waters and**

- **use of water furnished by precipitation.**

To meet demand, use is often made of all three resources simultaneously, where seasonal water availability permits.

Unlike public, urban, water supply where use is made of a (large) central abstraction system and reservoirs and a connected distribution system, what is typical of rural water supply is so-called "de-centralised" water supply systems where the beneficiaries often assist in constructing the system under self-help projects and later on become responsible for operating it.

Relatively small groups of consumers ranging from a single family to village communities or nomadic herding communities obtain their water supplies from small, often scattered and sometimes widely separated individual abstraction systems with no distribution system, water carrying traditionally being the domain of women and girls in rural areas.

What is typical of de-centralised groundwater abstraction **is dug or drilled wells or spring tappings. The lifting units in the systems are generally small, to match the number of consumers, the water resource and the generally limited constructional resources and their capacity is of the order of 1 m^3/h in the case of village wells and up to 5 m^3/h in the case of wells on pasture land.**

Lifting is generally carried out by traditional means operated either by hand or by draught animals, though use may also be made of mechanical lifting aids such as hand-operated or motor-driven (generally diesel) pumps, bucket chains, etc. Artesian wells, in which the water is

confined and rises to the surface without the need for lifting, are rare. In some cases water is lifted into community tanks, which are closed tanks of 2 - 6 m^3 capacity fitted with a tap.

The characteristic feature of abstraction from surface waters is small impoundment works (normally earth dams). The hallmark of precipitation water use is cisterns (ranging from buckets through water barrels up to closed tanks made of concrete, sheet steel or plastic) and the associated intercepting and collecting surfaces (roofs, sealed upland slopes, etc.).

The predominant method of conveying water between the point of abstraction and the point of consumption is still transport in portable containers or by donkey, generally a job done by women and girls. Supply pipes are rare and generally very short. Transport considerations mean that drinking troughs for livestock are generally sited immediately adjacent to the abstraction or collecting point.

An important part in rural water supply projects is played by local measures to regulate the supply, particularly when the amount of water available is restricted. Such measures include for example restrictions on the daily periods of withdrawal and pumping and on the volumes lifted, and measures to control consumption such as suitable pricing.

2. Environmental impacts and protective measures

2.1 Overview

Environmental impacts from rural water supply projects are possible and they are due primarily to the qualitative and quantitative exploitation which occur as a result of:

(a) the abstraction of water (overuse of the resource),

(b) the lifting, storage and distribution of the water, and

(c) the actual allocation made (requirements and mode of use).

As well as the above, there are also possible secondary and tertiary impacts on the environment in the event of

(d) increased demand due to positive feedback,

(e) overtaxing of the resources due to a good water supply for a short period, accompanied by overgrazing and gnawing of the vegetation and changes in accustomed modes of use.

Environmental protection measures will therefore be qualitatively and quantitatively orientated and hence will be chiefly concerned with strategies for preventing overuse of the water and threats to its hygiene. This means not simply measures that are technically feasible (e.g. limited well development geared to the technology available), but above all complementary efforts to produce organised self-help, in the form of instructional and hygiene

campaigns, with women playing a crucial role in these not just in the planning but above all in the implementation.

2.2 Quantitative overuse of water resources and threats to their quality

2.2.1 General

Water resources may be adversely affected not just quantitatively, i.e. in respect of their volume and temporal/spatial availability, but also qualitatively in respect of their quality and hence their fitness for use, which may occur due to pollutants, bacteria etc. The impacts on them exerted by rural water supply operations may affect them in the same way.

In cases where precipitation is collected, overuse is ruled out by the natural

limit on the amount of water collected (which is often small anyway), whereas in cases where supplies are abstracted from surface waters, threats may arise to the water resources, particularly in respect of quality.

Where the most serious adverse impacts are possible, however, is where supplies are abstracted from groundwater. In this case there may be permanent, irreversible deleterious effects on the resource both in quantitative and qualitative terms. Fossil groundwater is a non-renewable resource and as such it should, if at all possible, not be exploited in any way.

For groundwater abstraction, the open well is far more of a risk to water hygiene than a pumping system covered at the top.

In many cases, it is likely in rural areas with well-developed structures that, given the relatively small volumes abstracted for rural water supply, the total available resources will have sufficient regenerative capacity to rule out any threat of sustained overuse. However, if there are also other adverse factors operating, then undesirable overtaxing of the resources may very well occur.

2.2.2 Quantitative overuse of resources

2.2.2.1 Groundwater

Groundwater is the most sensitive resource and as such, the determining factor that governs its regenerative capacity is the recharge rate, which often works out to only a fraction of mean annual precipitation. The significance of the recharge rate can be seen from the following example:

- Where groundwater is recharged at 80 mm/a from precipitation, an average village well system composed of individual wells, with a system output of around 8,000 m^3 (around 10 hours' operation a day at 0.8 to 2 m^3/h), requires a watershed of 10 ha or 0.1 km^2.
- However, where the recharge rate is only one tenth of that quoted above, i.e. where it is only

8 mm/a, the watershed needed by the well system goes up to 10 times 100 ha, or to 1 km^2.

This example demonstrates the extreme sensitivity of the water balance in cases where groundwater recharge rates are lower than 10 mm/a, as they are in many of the arid regions of Africa.

Where the hydrogeological defining conditions are as follows, they can be taken as indicating a possible threat of quantitative overuse of groundwater reserves:

- **very low annual precipitation,**
- **high evaporation rates,**
- **largely impermeable and/or shallow aquiferous strata and**
- **a restricted number of perched aquifers.**

The above factors are outside human control but there are also other, use-related factors which may lead to overtaxing of groundwater resources:

- **excessively close grouping of wells/pumps, due for example to poor co-ordination or ignorance, causing the cones of depression of the wells/pumps to overlap and thus have an adverse effect on their yields,**
- **uncontrolled rises in the abstraction rates, due for example to enlarged livestock holdings and/or greater use of water for irrigation of agricultural land,**
- **wasting of water, due for example to excessive running of pumps or modes of**

operation dictated by overlarge lifting aids (pumps) or ones with a needlessly high output.

An essential prerequisite for preventing overuse is as accurate as possible a knowledge of the parameters governing the geohydrological balance, i.e. the inflow to and outflow from the watershed in which the use is taking place. Often, the basic data may not be available, and it may only be after observation over a number of years that adequate information on the parameters in question can be obtained, a fact that often militates against any early implementation of projects. Hence overuse may equally well be the result of over-hasty planning (or total absence of planning on the grounds that a project is only modest in scope) based on observations made over too short a period.

In countries in temperate latitudes, preserving groundwater resources has traditionally been the primary concern of water-management master plans (see the environmental brief on Water Framework Planning).

In arid regions, the need to preserve human life may sometimes mean that this primary concern has to be ignored and even fossil (non-renewable) groundwater abstracted. However, any sustained overtaxing of such resources must inevitably lead to the exhaustion of reserves and may thus, under certain circumstances, have highly adverse long-term repercussions on the conditions of life themselves.

Problems of a purely mechanical kind, though ones which have major implications for the

supply, often occur with hand pumping, for which a wide variety of different systems are employed. Often, the pumps break down for lack of only minor spare parts. The parts then prove to be unavailable or there is no money to procure them or no-one will accept responsibility for procuring them. As a result the well can no longer be used and the population are forced to return to using surface water of unacceptable quality.

It will be clear from the above that the questions of defined responsibilities, of the techniques employed and of what the subsequent water charges need to be in order to ensure uninterrupted operation and proper maintenance are the very ones that have to be covered in a project, and to be covered jointly with the target group with full involvement of, above all, the women who are responsible for fetching water.

2.2.2.2 Surface water

Earth dams of modest height (a few metres) are often built around or across rivers/bodies of water, or at the foot of suitable valleys or gorges in the associated watershed, to store surface water for various purposes (e.g. water supply, irrigation) and make it available for long periods or all the year round (see also the environmental brief Rural Hydraulic Engineering).

There will only be any impacts on the water balance, and particularly on the groundwater conditions, downstream of a small impounding work if the volume of impounded water amounts to a relatively high proportion of the discharge from the river or body of water when not intercepted (i.e. if it brings discharge to a level below the mean low water discharge MLQ).

Although this is seldom done, should the entire discharge be impounded then the watercourse will dry up and the water table will be lowered. It is advisable for a study to be carried out in each individual case, and an estimate to be made on the basis of its findings, of whether the volume of water abstracted (less losses attributable to use for example) will affect the ecology and if so how. At the same time, as accurate as possible an appraisal must be made of whether total impoundment is justifiable in the light of the serious impacts on the water balance downstream.

The infiltration of surface water to replenish already overused groundwater resources, with the added aim of cleaning the water as it seeps though the soil, can only be contemplated when the general hydrogeological conditions are suitable and when adequate reserves of surface water are available and it will therefore always be an exception. It makes better sense in cases like this for the water to be filtered above-ground or for a water harvesting system to be installed along the course of the river in the form of an impermeable impoundment wall for collecting water with facilities for withdrawal downstream and a filter structure facing upstream.

2.2.3 Qualitative aspects of overuse and storage

There are environmental impacts that are caused by the incorrect storage of collected rainwater and impounded surface water and by contamination and illicit use of the water as it is being conveyed in open channels. It is particularly in rural regions that the resulting hygienic risks of the transmission of waterborne diseases are high, in that, in them, surface water is

generally freely accessible to man and beast, the water concerned is not subject to any sort of quota-fixing, and health risks are, in general, not properly appreciated.

Deterioration of water quality is caused chiefly by suffusion with light and algal and plant growth and by pronounced warming of the generally static water. If there is also a rich supply of nutrients combined with a low rate of exchange of the water, then eutrophication processes may occur in the impounded bodies of water, which are generally shallow.

The health risks (malaria, bilharzia, diarrhetic diseases) posed by stored water of this kind are compounded by the proliferation of insects, by the possibility of human and animal excrement on the banks and shores, and by the discharge of waste water. Another possibility is pollution resulting from the use of pesticides in the watershed where the water is collected. In this connection, care must be taken to ensure strict demarcation of the watershed (as a water protection area) and physical separation of the water supply systems for humans from those for livestock (and, where necessary, filtering of the water abstracted).

Where rainwater is stored in cisterns, health risks arise as a result of deterioration of water quality, which may be caused by long residence of the water in the cistern in some cases, by choice of an unsuitable location (exposed to solar radiation), by lack of regular cleaning, by material-related effects (e.g. corrosion of sheet-metal cisterns), or by entry of dirt and animals (which die and decay in the cisterns) allowed by absence of covers or covers that do not seal tightly. Even chlorination of the water, though it may be employed to kill off bacteria, entails considerable health risks if incorrectly applied.

2.2.4 Qualitative aspects of non-piped distribution

There are typical impacts that are generated at distribution points both where these points are small open or pump-equipped wells and where they belong to systems for abstracting water from surface waters. There are a multiplicity of possible ways in which groundwater in general and the water in a well or body of water can be polluted. The main pollution sources producing individual health risks of infectious diseases that should be mentioned are these:

2.2.4.1 Close to the distribution point (well/water takeoff point)

- leaks from the motor or bucket drive (diesel fuel, lubricant), with open wells being more at risk here than closed wells with pumps,
- entry of pollutants as result of the items used

• for water withdrawal (dirty lifting buckets and carrying vessels),

• for the transportation of water by car, truck or beast of burden, where there is a risk of contamination with petrol, diesel fuel and excrement,

• for cleaning of the person and laundering (detergents, phosphates, faeces)

• for watering livestock, where there may be dung deposits, cattle mires, and greater insect infestation, and pesticides for pest control.

- **for filling and cleaning equipment for spraying pesticides for pest control.**

2.2.4.2 In the remainder of the watershed

- pollution caused by totally different activities not directly related to water abstraction such as agriculture (fertilizers, semi-liquid manure, pesticides), artisanal activities and light industry (oil, diesel fuel and petrol, etc.), and the disposal of waste water and solid waste.

A point which needs to be made in connection with the preservation of groundwater quality is that, desirable though it may be to introduce water protection areas to prevent qualitative impairment of the groundwater by humans and animals, it is difficult to achieve in practice and it is only feasible if the population is enlightened as to the need for it. If however some initial protective measures were taken in the immediate vicinity of a water takeoff point (well, pump, community tank, surface water withdrawal point, spring), this in itself would be a first step on the way to mitigating the above risk and hence to improving the health situation. What will be needed here will be work to instruct the public and increase public awareness and this will need to be concentrated above all on women, who are responsible for fetching water and for domestic hygiene and thus family health.

A start can be made by fencing off water takeoff points such as village wells and making sure that they are allocated to specific uses (human/animal, water fetching/washing and laundering/livestock watering) and are well separated physically for this purpose and that

there are safe and reliable facilities for discharging the waste water. As a further step towards procuring clean, workable water takeoff points geared to the different needs that exist, what also needs to be done is to introduce a monitoring and inspection system for maintaining and repairing the points and stopping any environmental damage. In this system women will, once again, have a crucial part to play (as well overseers for example).

Given the growing number of car repair shops and filling stations in many countries, other focusses of attention will need to be the development and installation of petrol and oil separators.

2.3 Increase in demand resulting from positive feedback

The existence of a convenient and efficient water supply system, coupled with a general betterment of conditions in rural areas, may give rise to increases in demand.

This will mean a rise in abstraction, generally uncontrolled and chiefly from groundwater, and this in turn will accentuate the quantitative impacts on the resource concerned. Up to this point, and given the small volumes consumed to meet basic needs (see section 1), the matter of waste water will have been of very little concern, but now evidence will begin to be seen of the adverse consequences it can have on the quality of surface water and groundwater and thus, indirectly, on the health of humans and animals. The first steps that can be taken to combat these consequences are such things as instruction in hygiene and the construction of VIP latrines.[2)] This is another case where women, the persons responsible for obtaining water and

ensuring domestic hygiene, will need to be actively involved at the outset.

2) Ventilated improved pit-latrines

2.4 Overuse resulting from a good water supply

A good water supply in rural areas can lead to an increase in livestock holdings, with all the adverse consequential impacts this may have such as overgrazing and gnawing of the vegetation and compaction of the soil. In the longer term there may also be tertiary impacts, such as changes in the microclimate caused by attacks on vegetation (e.g. gnawing of trees by goats causing changes to the ecologically important micro-climate close to the ground) or water or wind erosion where the all-important top soil is stripped away as a result of overgrazing of the vegetative cover.

Detrimental impacts may also arise from the physical layout and position of the supply points (e.g. wells) when the latter are not geared to the socio-economic needs of the target group. Groups from a nomadic population for example need supply points that lie within a few day's march even when the weather is bad and/or fodder is short. This may not be possible in certain instances, so the average length of stay at a given watering place is extended accordingly and the risk of overuse becomes greater. In the worst case, the nomadic way of life might have to be abandoned in favour of a quasi-sedentary way of life, and this would give rise to impacts whose social and socio-economic consequences would be difficult to foresee.

In such cases, project schemes must be drawn up jointly with the target groups and must allow for existing, often traditional water and grazing rights though at the same time, by making provision for enlightening people and making them aware of the interrelationships that exist (and possibly by means of water pricing too where appropriate), they must also afford resource-saving solutions.

3. Notes on the analysis and evaluation of environmental impacts

A vital prerequisite for both analysing and evaluating environmental impacts from rural water supply is a determination of the usable water supply. Factors that have a crucial bearing on the possible intensity of use in this case are regenerative capacity in the case of groundwater and the watershed and its yield curve with time in the case of surface water.

Particular risks attach to the use of fossil groundwater, for this is non-renewable.

Incorrect estimates of the available water supply are possible particularly in arid and semi-arid regions, where not only may there be marked fluctuations from year to year in the yield but there may also be no appreciable regeneration of the resources for a number of years due to the absence of precipitation. Under these circumstances it is only justifiable to make estimates by reference to average values measured over many years when the groundwater-bearing aquifers are thick and cover large areas.

Where the resources are affected by unfavourable natural conditions, this will restrict the opportunities for providing a decentralised supply, and particularly a decentralised supply to rural centres of population, where the quite heavy concentration of population would mean that a number of wells spaced relatively short distances apart would be needed but where the wells would affect each other's yields. Further restrictions may arise from, for example, pollution of the groundwater by refuse pits and soakaways, washing places, and drinking troughs for livestock.

Surveys of the current situation and the potential changes (in population, per capita consumption, commercial activity, etc.) will be needed, together with an analysis and evaluation of the local impacts of the potential hazards.

One of the most essential prerequisites for analysing and evaluating the environmental impacts of rural water supply is a knowledge of the defining climatic and hydrological conditions (direction and strength of winds, precipitation, evaporation, temperatures, and water levels and water tables), which have to be allowed for at the outset in connection with yield and recharging and the resulting opportunities for use. In many countries the basic data available, in the form of uninterrupted sets of measurements extending over a period of years, may be deficient in that the measurement points may be few in number and, as often happens, outside the project region, and because of this it may be necessary to engage in additional long-term measurement surveys to acquire the above knowledge.

This process, though essential to ensure that planning and implementation have proper

scientific backing and that sustained use will be possible, often runs counter to the urgent need for supply systems to be created quickly and may meet with incomprehension on the part of, for example, the people affected.

Also, water supply is a sensitive area, and this being so it will be necessary to call on not just engineering knowledge but sociological and ethnological knowledge too. Important questions relating to matters such as the structure of the society, the official/traditional organisation of villages, water consumption customs, domestic hygiene, the income situation (in relation to charges for water), water and garzing rights, and the role of women all need to be clarified with the people involved, if possible in the early stages.

Generally speaking, what standards (limit values, guidelines and directives) relate to are water quality requirements (including hygienic conditions) on the one hand, and limits for heaviness of use for (subsequent) competing applications. Binding standards for ecological and socio-economic implications and impacts do not exist, and there will therefore be a continuing opportunity for differing interpretations to be placed upon them.

There are, for a basic range of constituents, recommendations of world-wide ambit (see section 6) on drinking water requirements, but though many countries with no pertinent national legislation of their own may already be following these recommendations, there are major problems in checking and ensuring compliance with them in practice.

Standards for the limits on possible heaviness of use (e.g. per capita consumption figures for

humans and animals, see also section 1) were, in essence, drawn up simply as rule-of-thumb figures. However, given the multiplicity of factors to be allowed for, it seems doubtful whether they will be capable of general application and for this reason preference should always be given to a funded regional investigation.

By appropriate improvement of public understanding and awareness, an attempt should be made in every project to bring into being demands for environmental protection that are as high as possible within the limits set by socio-economic and cultural factors, with particular importance being attached to the involvement of women in their role as the persons responsible for water supply in rural areas.

4. Interaction with other sectors

Where rural water supply has its closest points of contact is with all sectors that create further demand for water, that have the use of water as one of their direct or indirect objectives, or that affect water quality or restrict the quantity of water available.

The chief sector concerned here is agriculture (see also other broadly agricultural areas[3)] in that it may involve the use of the same supply of ground and surface water, with the possibility of added impacts generated by adjacent abstractions. There may possibly be interaction too with the following sub-sectors, and such interaction should be checked for its consequences in

each individual case:

3) plant production, plant protection, forestry, fisheries and aquaculture, irrigation, livestock farming, and agro-industry.

- **Water Framework Planning**
- **Rural Hydraulic Engineering**
- **Solid Waste Disposal - Collection, treatment and disposal**
- **Wastewater Disposal (and rainwater) - Collection, treatment, disposal/discharge**
- **River and Canal Engineering**
- **Erosion Control**
- **Large-scale Hydraulic Engineering**
- **Spatial and Regional Planning.**

Water supply occupies a key position in determining how, and how intensively, an area or region can be developed and it therefore has an impact on all projects and sectors that involve planning to preserve, improve or develop the infrastructure.

5. Summary assessment of environmental relevance

Rural water supply projects are contributory means to ensuring the long-term preservation of

human life and the quality of life.

It is perfectly possible for the planning and execution of rural water supply projects to be orientated towards meeting the demands of environmental and resource protection. In broad terms, what needs to be remembered is that only seldom does the individual facility such as a well, pump set or collecting basin/water tank create any major environmental impacts of itself, and that if there is environmental damage it normally does not occur until such facilities become concentrated and overused, particularly in connection with livestock watering.

Handpumps are the most widely used aid for water lifting, and it is particularly where they are employed that care must be taken to see that the equipment selected is robust and easy to maintain and obtain spares for, because if they do fail this will jeopardise the underlying goal any project will have of providing a sustained supply of good quality water and will compel the population to revert to using open watering points with their attendant health risks[4)].

4) Women have traditionally been responsible for water supply and it is they who will need to be trained not only to operate but also maintain the pumps.

To sum up, the following is a list of criteria that must be met for the better environmental orientation of a project:

(1) The time-dependent total water yield must be studied and long-term hydrological and climatic trends must be examined;

(2) It must be decided what the desired sociographic structure of the rural region is to be and what limits are to be set for its possible development, with due allowance for the structures that tradition and ethnicity have put in place;

(3) Planners must be bound by an overall utilisation scheme that makes a quantitative apportionment of the available supply and lays down priorities among uses;

(4) Technology geared to the utilisation scheme laid down must be developed or applied, with active involvement of target groups at an early stage, steps must be taken to ensure that subsequent operation and maintenance will be possible (charges for water), and the transferability of solutions successfully employed elsewhere must be carefully vetted.

Experience teaches that hierarchical levels of planning are a necessary prerequisite for meeting the above criteria and that it makes good sense for rural water supply projects to be subordinated to rural regional development programmes. It is particularly important to have things structured in this way because the opportunities for control in the sensitive area of water supply (e.g. by restricting abstraction) are very limited and security needs to be built no later than the planning stage.

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12. Wastewater disposal

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1. Scope

1.1 Definitions

Wastewater is water whose properties have been changed by domestic, industrial, agricultural or other use and water (sewage) discharged with it during dry weather as well as the run-off and collected water (rainwater) from built-up or paved areas due to rainfall. Sewage also includes the liquids discharged and collected from waste treatment and storage

plants.

Community water management, a division of water resources management, comprises the sum of all targeted environmental-protection measures to supply communities, trade and industry with satisfactory drinking or industrial water as well as the disposal of domestic, commercial and industrial wastewater from these areas.

Wastewater disposal, a division of community water management, essentially comprises the collection, removal, treatment and disposal of wastewater.

The generally accepted rules of the art comprise those rules which have been tested in practical applications, such that the majority of the people working in this specialist field regard the processes, plant, facilities or operating methods in question as correct (3). The technical nature of the rules may vary according to the requirements in individual countries.

The state of the art is the state of development of advanced processes, plant, facilities or operating methods, guaranteeing the practical suitability of such technical measures. To determine the state of the art, an assessment must be made in particular of comparable processes, plant, facilities or operating methods which have been successfully tested in operation (4). The technical nature of the state of the art may vary according to the requirements in individual countries.

1.2 Problems

The world-wide industrial development of recent decades, with its effects on the manufacture of goods and on the consumption patterns and health habits of the population, has led to an appreciable increase in the volume of wastewater. In this respect, targeted wastewater disposal (WWD), involving careful analysis and taking into account not only the local conditions and options but also the environmental aspects of the relevant plant, can bring about the necessary improvements. As a rule, these relate to measures not only in the fields of wastewater technology, but also in the fields of law, administration, business management and organisation.

The necessary improvements should also aim to achieve reasonable representation for women, as one of the target groups, in the institutions and bodies responsible for wastewater disposal. This is the best way to guarantee that their legitimate interest in participating in the development and implementation of administrative, business and environmental monitoring regulations will be served.

1.3 Objectives

The controlled disposal of sewage and rainwater forms a vital part of the infrastructure of human settlements built on principles of hygiene and hence is fundamental to efforts to improve the quality of life. Furthermore it is an essential component of water quality management, whose aim should be:

- to maintain the ecological equilibrium of bodies of water and - where it has been disturbed -

to restore it
- to ensure a water supply of guaranteed quantity and quality for the general public as well as for trade and industry - with particular emphasis on long-term sustainability - and
- to enable all other water uses which serve both the well-being of the general public and the legitimate needs of individuals in the long term (5).

Figures show that in many countries there is a marked imbalance between water supply and wastewater disposal. This is because, in the countries in question, clear priority has been given to the matter of water supply, without paying at least equal attention to the necessary development of wastewater disposal facilities. The same also applies to the relationship between water supply and wastewater disposal in commercial and industrial establishments.

Within this environmental brief, questions of municipal wastewater disposal also take high priority. Questions of commercial and industrial wastewater disposal - in view of their complexity and scope - can only be dealt with selectively.

1.4 Stages of wastewater disposal

The area of municipal wastewater disposal may in particular comprise the following disposal stages:

- **wastewater collection**
- **wastewater removal**

- **wastewater treatment**
- **wastewater discharge**
- **disposal of faecal matter (from latrines and similar installations)**
- **sludge treatment.**

The disposal stages mentioned may refer both to sewage (domestic, trade, industrial) and to rainwater. In this respect one should not forget percolating water, which includes e.g. groundwater which penetrates sewers through leaks, or drainage water which results from groundwater lowering and is removed via the drainage network.

In the individual disposal stages the following wastewater processes take place:

- **wastewater collection: collection of wastewater at source using connection, down and soil pipes as well as by wastewater collection pits, cesspits, latrines etc.**
- **wastewater removal: conveying of wastewater through sewers (in the case of rainwater also through open channels) using separate, combined or sewage-only systems (the latter without central removal of rainwater).**
- **wastewater treatment: application of physical, biological (aerobic or anaerobic) and chemical processes with the aim of minimising the substances contained in the wastewater which are harmful to the environment, and in particular to water, or of reducing their harmful effect to the necessary degree.**
- **wastewater discharge: return of the wastewater (usually after treatment) to the natural water cycle (e.g. using clarification basin overflows for counter-overflow**

basins in the combined system, rainwater overflows in separate systems or effluent channels in sewage treatment works).

- sludge treatment: processing sludge for recycling or disposal (see DIN 4045, (6)).

The environmental impact of the disposal stages described should first be considered individually in order to assess their importance. An integrated assessment, also taking into account any significant interactions, should then be carried out for the project.

In the case of commercial and industrial wastewater disposal, one should proceed in a similar way on the basis of the above-mentioned disposal stages, for both directly discharging and indirectly discharging wastewater producers. However, there is one further decisive disposal stage which must be considered first, namely the stage involving the avoidance or reduction of wastewater, taking into account the quantity (volumetric flow) and the pollutant load (mass flow). In this respect questions of the material input of production as well as that of production itself, i.e. its process-side, are particularly important.

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2. Environmental impacts and protective measures

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2.1 Introductory notes

In spite of the basically environment-oriented objective of wastewater disposal, various problem factors may arise which may be impossible or difficult to overcome:

a) technically/economically unavoidable emissions (residual emissions), from the wastewater disposal installations which have an overall impact on air, soil and water, on people and on ecosystems

b) unforeseen increase in volume of sewage from dwellings (due to changes in lifestyle)

c) unforeseen increase in volume of sewage from commercial and industrial establishments (due to production increases, fluctuations, seasonal operation)

d) eutrophication phenomena in the receiving body of water into which the treated wastewater is discharged, during long periods of low rainfall

e) adverse consequences of using sewage sludge or composted refuse/sewage sludge in agriculture for the purposes of recycling.

From the start, reasonable allowance should be made for the above-mentioned problem factors in all project management activities, in order to minimise from the outset any conceivable

effects, using suitable measures of an organisational, structural and operational nature, and in certain circumstances also with recourse to emergency measures. Furthermore, wastewater disposal measures are to be planned taking into account local conditions so that they satisfy the generally accepted rules of wastewater technology or the state of the art (after careful consideration where necessary).

Considering each relevant sub-sector of wastewater disposal in turn, the potential typical environmental impacts are as follows (7), (8).

2.2 Typical environmental impact

In any wastewater disposal project, it is vital to decide whether to adopt:

- **a decentralised local sewerage system (individual sewerage system at each source with wastewater collection pits, cesspits or small sewage works, latrines, etc.) or**
- **a central local sewerage system (collective sewerage system comprising a sewer network with all necessary installations, to collect, divert and deliver the wastewater produced at the individual sources to one or more (central) sewage treatment works(s)**

Different environmental effects occur here, the most important of which are set out below.

2.2.1 Impact of wastewater collection and removal

2.2.1.1 Decentralised sewerage system

Decentralised wastewater disposal may have the following adverse effects on the environment:

For the user, individual sewerage systems mean higher expenditure on maintenance and upkeep compared with systems connected to a central sewerage system. If not properly constructed this can lead to problems such as

- poor quality of the effluent from the small sewage works (if the sludge settling chambers are not regularly and properly emptied) and hence the contamination of the receiving body of water,
- frequent running of emergency overflows from pump shafts if the pumps are not properly maintained and hence contamination of areas which should only receive effluent in definite cases of emergency,
- contamination of the subsoil and particularly of groundwater in the case of dry closets (aerated/unaerated latrines), cesspools, percolation systems (particularly soakaways after aerobic or anaerobic biological wastewater treatment) leaking cesspits etc. in particular where the hydrogeological conditions are unsuitable,
- health hazards due to the operation of individual sewerage systems (e.g. danger of infection through direct contact when emptying pit contents; through insects and rat infestation),
- health hazards upon final disposal (discharge) of sludge from small sewage works or

pit contents from collection cesspits, where not properly executed,
- aesthetic and odour nuisance,
- no possibility of central removal and treatment of commercial/industrial wastewater together with domestic sewage.

Beneficial effects of decentralised wastewater disposal on the environment may be as follows:

- The natural water cycle is scarcely interrupted or disturbed by the proper collection and removal of rainwater (this considerably reduces the amount of percolation from rainwater).
- There may be a greater incentive to reduce water consumption (increased consumption will lead to substantially higher costs of removal of pit contents).
- (Inefficient) receiving bodies of water are not subject to sporadic or sudden contamination at the rainwater overflows and outfalls or at the outfall works of sewage treatment plants.
- Eutrophication or desertification phenomena in receiving bodies of water are largely eliminated.

2.2.1.2 Central sewerage system

The beneficial effects of a decentralised local sewerage system mentioned in 2.2.1.1. are absent in the case of a central local sewerage system (central wastewater disposal). Indeed, their absence is a positive disadvantage. In addition, a central sewerage system has the

following adverse effects on the environment:

- With inadequately designed or manufactured pipe couplings, serious leakage may occur (penetration of groundwater; hydraulic overload of pipes, pumping station and sewage works; leakage of wastewater; contamination of subsoil or groundwater).
- With large wastewater pumping stations, noise and odour nuisance may occur if

they are too close to neighbouring buildings or

sound insulation, aeration, ventilation and deodorization are lacking or inadequate.

Major positive effects of a central sewerage system are in particular the following (9):

- protection of the population from health hazards caused by infectious germs transmitted directly or indirectly by water, e.g. in the event of contamination of groundwater used for individual drinking water supplies or by direct contact with the wastewater.
- protection of the population from aesthetic nuisance caused by substances in wastewater which readily putrefy.
- protection of the population from flooding of cellars and storage rooms during storms.
- safeguarding of motor vehicle, bicycle and pedestrian traffic, even in case of heavy rainfall.

- possibility of removal and treatment of commercial or industrial wastewater together with domestic sewage.
- protection of utilisable groundwater reserves from contamination by substances contained in (domestic) sewage, especially nitrogen compounds.

2.2.1.3 Special wastewater disposal processes

In certain wastewater disposal areas, a combination of these two disposal systems may be appropriate. In some cases it may also be worthwhile in terms of ecology and water management to have a sewerage system in which only the sewage is centrally removed, but not the rainwater.

Moreover with the dual system, overground or underground removal of rainwater may also be a good idea in terms of ecology and water management if the sewage and rain water are consistently separated, taking care to ensure that the rainwater remains as "clean" as possible. In other words: The rainwater, which is relatively clean from the outset, should not be deliberately mixed with a medium (in this case sewage) whereby it likewise becomes a dirty medium. With careful and proper operation of such a dual system, the pollutant load in the receiving bodies of water can be substantially reduced, for the following reasons in particular:

- There is no need for rainwater or mixed water outfalls, therefore there are no mixed water effluents, which can otherwise cause serious pollution of receiving bodies of water, particularly after long dry spells.

- Only sewage passes to the central treatment works, so that the wastewater flow at the intake is considerably reduced and homogenized, thus considerably improving the efficiency and safety of the works.

2.2.2 Impact of wastewater treatment

2.2.2.1 Introductory notes

The qualitative and quantitative criteria for proper wastewater treatment - and so for its environmental impact - are derived primarily from emission and immission standards, which in turn are derived from the relevant water management conditions and from the legislation, regulations etc. in force. In many countries the latter rarely exist or where they do exist are inadequate. Direct application of, say, German, EC or American laws and regulations rarely provides an appropriate solution. Rather, it is necessary to develop measures suited to the prevailing general constraints and to implement them with the involvement of the local population.

2.2.2.2 Emissions from (central) sewage works

The substances in wastewater which pollute the water and sewage sludge in a public (municipal) wastewater disposal plant require a variety of processes and facilities to eliminate or reduce them. When planning a sewage works these are combined in a certain way or arranged in series (treatment stages). Table 1 summarises the technically feasible processes

for treatment of municipal wastewater on the basis of the present level of development - with their treatment capacities expressed as the degree of efficiency (5).

The procedures in question are listed in the sequence in which they normally occur in the treatment stages of a sewage works, in order to achieve optimum results. Most importantly, the table shows the anticipated impact on the receiving body of water, i.e. pollutant emissions as a percentage of the concentrations in the incoming wastewater.

***Table 1* - Efficiency of different wastewater treatment processes (expressed in %)**

Process	Suspended solids	BOD_5 1)	COD 2)	Phosphorus Ptot	Nitrogen (NH_4-N)
Mechanical treatment Biological aerobic treatment	40 to 70 85 to 90	25 to 40 85 to 95	approx 15 approx 80	approx 15 approx 30	approx 7 approx 40
Additional reduction of residual substances					
Micro-strainer Filtration Chemical precipitation	20 to 40 50 to 80 70 to 90	5 to 10 10 to 20 50 to 85	5 to 10 5 to 20 40 to 70	- - 50 to 90	- - 0 to 30

Activated carbon adsorption	50 to 90	approx 95	approx 90	approx 90	approx 10

1) Biochemical oxygen demand after 5 days

2) Chemical oxygen demand

For the efficiency of anaerobic wastewater treatment processes (highly suitable in countries with hot climates) please refer to (10).

Sewage works affect the environment not only in terms of water-related emissions, but also in terms of

- **noise**
- **odours and**
- **air pollution (aerosols).**

As a rule, however, it can be assumed that these types of emissions are less important than the water-related emissions of a sewage works (wastewater discharge).

2.2.2.3 Emissions of small sewage works

In the case of decentralised wastewater disposal systems individual or small sewage works

may be involved (see 2.2.1.1). The disposal of the treated wastewater can either take place via discharge into a body of surface water or via discharge into the subsoil (seepage, percolation).

As regards permissible emissions of small sewage works and their environmental impact one must basically make a distinction between two types of works:

a) works without wastewater aeration, also called septic tanks (with exclusively mechanical or partly biological (anaerobic) treatment) and

b) works with wastewater aeration and mechanical/biological treatment. With works of type a), biological efficiency of 20-25% and in exceptional cases as much as 50% is obtained. In works of type b) efficiencies as high as those of central sewage works (see 2.2.2.2, Table 1) can be achieved, as long as they are properly designed and operated.

By adding an underground seepage plant, a sand filter pit or a soakaway, the wastewater in works of type a) can undergo further biological treatment and thus - provided the hydrogeological conditions are suitable -passed to the subsoil. The discharge of wastewater from works of type a) directly into surface waters is generally not acceptable.

2.2.2.4 Impact on bodies of water

Inadequately treated wastewater may disturb the natural self-purification capacity of receiving bodies of water based on physical, chemical and biological processes and cause other

nuisances.

Undissolved wastewater components cause deposits of sludge, particularly in slow-flowing and standing waters, e.g. ponds, lakes and shipping canals, and also in blind river arms, creeks, reservoirs etc. If these originate from organic sediments, there will also be decomposition phenomena with the development of decomposition and fermentation gases, consumption of the oxygen dissolved in the water by absorbed decomposition products, inhibition of life forms or even mortality of microorganisms and fish. Many organically polluted commercial or industrial wastewaters favour the development of "sewage fungus" in flowing waters containing oxygen, particularly in cold seasons. Torn-off fungal particles develop into fungal drifts and, where the current is weak, frequently cause secondary sludge deposits with the results mentioned above.

Dissolved and organic constituents of wastewater require the presence of a certain quantity of oxygen in the water for their biochemical breakdown, where this occurs aerobically. This is determined in the same way as in the wastewaters themselves and is hence called biochemical oxygen demand.

Where the oxygen content or the oxygen uptake capacity of a receiving body of water is not sufficient for the biochemical oxidation of the organic substances fed into it, their further breakdown proceeds anaerobically. This results in the bacterial reduction of nitrates, sulphates, oxygen-containing organic compounds etc. to form carbon dioxide, hydrogen sulphide or sulphides, ammonia, nitrogen and other decomposition products. Methane is also

formed in digested sludge (14). Anaerobic decomposition processes caused by oxygen deficits disrupt the largely aerobically structured self-purification capacity of a body of water, and in serious cases may even cause it to fail completely. Such problems can also occur in a body of water under certain conditions even if treated wastewater is discharged in the proper way, i.e. in accordance with the rules of the art. One must then however assume that the self-purification capacity of the body of water is insufficient with the given discharge conditions. In such cases more stringent standards must then be applied for wastewater discharges, in order to meet or restore the required water quality targets (see 3.3).

Besides the problems caused by lack of oxygen in biochemical oxidation, eutrophication, i.e. the accumulation of plant nutrients in the water, particularly phosphorus and nitrogen, is an important factor. This "over-fertilisation" causes a mass development of plant material, in particular water plants (foliage plants) as well as blue, green and filamentous algae. Controlled (aerobic) decomposition of the dying matter is then no longer possible and this results in the above-mentioned anaerobic water-polluting decomposition processes.

The water may be polluted by a number of other substances having a toxic effect on aquatic fauna besides phosphorus and nitrogen. These include heavy metals, volatile halogenated hydrocarbons (e.g. trichloroethylene), non-volatile halogenated hydrocarbons (e.g. chlorobenzols), dioxins, pesticides and polycyclical aromatic hydrocarbons (e.g. fluoranthene).

As aquatic fauna differ in their sensitivity to environmental burdens or pollution, they can be used as indices of contamination (bio-indicators). This is particularly true of burdens caused by

lack of oxygen following the decomposition of organic matter and of toxic burdens. The saprobic system is based on this (7).

2.2.3 Impact of disposal of faecal matter

Much of what has been said in 2.2.1.1 ("adverse effects of decentralised wastewater disposal on the environment") apply here too. The following typical (adverse) effects of the disposal of faecal matter (in aerated/unaerated latrines, cesspools and collection pits) should be mentioned here:

- **health hazards due to the use and the emptying of latrines and collection pits (risk of infection due to direct contact with the faecal matter; insect and rat infestation etc.)**
- **contamination of the subsoil, and particularly of the groundwater too, if the hydrogeological conditions are unfavourable**
- **health hazards upon final disposal (discharge) of the faecal matter, where not carried out properly**
- **aesthetic and odour nuisance.**

Beneficial effects: See also 2.2.1.1 ("beneficial effects of decentralised wastewater disposal on the environment").

2.2.4 Impact of wastewater discharge

As stated in 1.4, wastewater discharge means the return of wastewater to the natural water cycle. This takes place in both disposal systems (decentralised and central).

Regarding the impact of wastewater discharge in the case of decentralised wastewater disposal, see 2.2.1.1 and 2.2.2.4.

Apart from likely noise and odour emissions, the effects of wastewater discharge in the case of central wastewater disposal manifest themselves mainly in the pollutant burden imposed on the receiving body of water, caused by the discharge from the central sewage works. Rainwater outfalls in a combined system can also have an impact on bodies of water. Furthermore, what is said in 2.2.2.4 also applies to the impact of wastewater discharge in the case of central wastewater disposal.

2.2.5 Impact of sludge disposal

2.2.5.1 Sludge disposal in central wastewater disposal

The sludge produced in a central sewage works must be treated in the course of disposal. The most important treatment stage is stabilisation; this may be carried out anaerobically or aerobically (7), (8). In the case of anaerobic treatment (digestion) of the sewage sludge, sludge digestion gases are produced which are largely odourless if the digestion process is carried out properly, i.e. through alkaline fermentation or methane fermentation (8). The main gases produced are carbon dioxide, nitrogen and methane.

Bearing in mind that recycling is required wherever possible, agricultural use of suitably pre-treated municipal sewage sludge should, if possible, be regarded as the correct disposal strategy for this sludge.

This should not however lead to accumulations of heavy metals in the soil, as these can pose a threat to people and animals via the food chain, particularly in the case of the highly toxic heavy metals cadmium and mercury.

If one considers the impact of sewage sludges in terms of their value as a source of raw material for agriculture, one should note (15):

> **- Sewage sludges are valuable primarily as phosphate and nitrogen fertilisers, but also because of their calcium and magnesium content; on the other hand, the potassium content is negligible. The organic matter content of sewage sludges also has a certain value. It is therefore only logical to use recycled sewage sludges for agricultural purposes.**
> **- Sewage sludge which contains an excess of toxic components or which may have other adverse effects must not be used. Negative effects such as**

damage to soil organisms and plants (phytotoxicity),

damage to the health of humans and animals as a result of excessive absorption through the food chain (via accumulations in plants);

adverse consequences for public hygiene

may be caused by an excess of potentially toxic elements.

- The plant availability of all components is a crucial factor. With agricultural recycling of sewage sludges the

phosphate content available to plants,

nitrogen content available to plants,

pollutant content available to plants,

are of prime importance. The last of these is determined by the content of seven potentially toxic non-ferrous metals (cadmium, chromium, copper, lead, mercury, nickel, zinc) in sewage sludges, as well as in the soils on which the sludge is to be spread.

Concerning the impact of sewage sludges used in agriculture, in conjunction with production of waste/sewage sludge compost, see also (16), (17), (18), (19).

2.2.5.2 Sludge disposal in the case of decentralised wastewater disposal

The sludge produced in decentralised disposal systems in small sewage works is mostly treated anaerobically. Where such a sewage works is operated correctly, no significant odour nuisance

or hygiene problems should occur (20), (21). What is said in 2.2.5.1 applies here too, particularly as regards sludge disposal.

As the sludge to be removed from small sewage works is not always uniformly or sufficiently stabilised or sterilised (particularly in the case of mixtures of faecal matter and carrying water in wastewater collection pits), it may be a good idea to have secondary digestion carried out centrally, e.g. in open earth basins or tanks. This applies particularly where agricultural use is envisaged. Such a simple method of secondary sludge treatment is acceptable wherever the extra work involved and the sometimes unavoidable odour emissions are a comparatively minor problem.

2.3 Avoidance and safety measures

2.3.1 Wastewater avoidance

Wastewater which has not been produced does not need disposal! In other words, the use of appropriate procedures and measures to reduce the volume or avoid producing wastewater takes pressure off the capacities of wastewater disposal systems.

In the domestic sphere, wastewater can largely only be avoided through water-saving by the general public, e.g. through the installation and use of water-saving sanitary installations, etc. Such measures should not however be to the detriment of health and the proper collection and removal of wastewater. This also depends on individual citizens having the necessary

motivation and understanding, which can be promoted by means of appropriate and regular information campaigns by the authorities and corporations responsible for wastewater disposal.

The positive effect of introducing progressive consumption tariffs on the water-saving behaviour of the general public should not be underestimated.

In the commercial and industrial sphere, depending on the sector from which the wastewater originates, specific plans should be developed to reduce the volume of wastewater. Such considerations usually centre on the recycling (multiple use) of process water, if necessary with the help of efficient treatment measures. Strict separation of sub-cycles is often highly advisable in this regard (14), (22).

2.3.2 Safety measures

2.3.2.1 Introductory notes

In this section, the term "safety measures" is used to denote all those measures which serve to minimise and compensate for the environmental impact and, where applicable, to make up for disturbances of the natural order.

2.3.2.2 Safety measures in wastewater collection and removal

In the design, construction and operation, primarily of central sewerage systems, but also of decentralised sewerage systems, the objectives should be as follows:

a) safe collection and removal of sewage and rainwater, not least in order to protect against disease
b) maintenance or improvement of the quality of surface water and groundwater
c) construction of permanently watertight sewers and repair of leaking sewers, pressure pipes and drains
d) optimisation of drainage works.

The above objectives can be achieved in particular by the following measures or procedures:

a)

- appropriate and adequate dimensioning of sewers and storage chambers to cope with peak flows (avoidance of flooding of properties, roads and land)
- suitable routing of sewers and arrangement of outfalls (in combined systems);
- flow control installations
- use of materials which fully meet the technical and hygiene standards.

b)

- reduction of discharge volumes (overflow frequency, discharge total, duration, load)

at the outfalls of combined sewerage systems
- elimination of faulty connections in dual systems (with rainwater and sewage channels)
- reduction of volume of wastewater (rainwater, sewage and mixed water) e.g. by rainwater percolation, cooling and industrial water circuits in commercial and industrial establishments, reduction in water consumption (see 2.3.1)
- prevention of water inflows from ditches, springs, streams and drainage pipes (to be carried away only in exceptional cases and only in rainwater sewers in the dual system, with allowance for possible flooding).

c)

- use of high-grade components (particularly pipes) and sealing materials/sealing elements which behave well under long-term stress. This prevents, on the one hand, penetration of groundwater and percolation water into the sewerage network and, on the other hand, leakage of wastewater and its constituents into the subsoil, and hence into the groundwater.

d)

- provision of qualified and well-motivated personnel for monitoring, maintenance and servicing work
- provision of adequate resources (sufficient tariffs) to cover the costs incurred (23).

2.3.2.3 Safety measures in wastewater treatment

To avoid harmful pollution of the environment and particularly of surface waters, the following principles in particular should be observed:

- **It is vital to determine as accurately as possible the composition and quantity of the wastewater produced and flowing to the sewage treatment works, particularly taking account of the short-term variations in domestic sewage quantities (daily maximum, daily minimum), quantities and constituents of commercial and industrial sewage (pre-treatment installations may be needed on the industrial sites in question) and the rainwater discharge conditions in the drainage area (7), (8)**
- **Reasonable allowance must be made for climatological conditions (level and distribution of annual rainfall, hours of sunshine, mean annual, monthly and daily temperatures etc.)**
- **The treatment capacity of the sewage treatment works must be appropriate to the ecologically acceptable and use-related load capacity of the receiving water system, paying close attention to the existing and anticipated preloading.**
- **All relevant technical and health regulations must be complied with when using treated wastewater and sewage sludge on agricultural land.**

Where it is necessary to apply the technologically simplest wastewater treatment processes, even if the work requires more land and manpower, and particularly in countries with a hot and very sunny climate, aerobic wastewater oxidation ponds without artificial aeration are

suitable (with or without a preceding anaerobic stage). They have proved to be a highly successful method of treatment (7), (8), (24), (25), (26), (27), (28). The operational and ecological advantages of these systems are:

- **simple management; low maintenance and upkeep cost of system components**
- **discharge is highly suitable for irrigation purposes**
- **disinfection is quite adequate if the holding times required by the system are adhered to (total reduction of bacterial burden 97-98 % and more)**
- **low odour emissions under proper operating conditions and low volume of stabilised sludge.**

Furthermore, with a view to safeguarding resources, particularly in countries with a hot climate, closer attention should be paid to processes utilising the valuable substances which the wastewater contains (wastewater utilisation). These include various digestion processes (biogas extraction), processes for agricultural exploitation (fertiliser production) after adequate desludging and fish pond processes (nutrient utilisation) (10), (29), (30), (31), (32).

Adverse effects occur mainly when the principles listed at the outset are not observed. In the case of oxidation ponds it is also worth mentioning that although these have a good buffer capacity to cope with sudden large quantities of wastewater, persistent operating problems are to be expected if wastewater with toxic constituents is delivered to the ponds, which in particular causes damage to the aerobic biosystem. Several weeks may pass before this is fully restored and the plant recovers the required treatment capacity, during which time the

receiving body of water may be subjected to undesirable levels of pollution.

The following environmental protection measures can be taken to combat other non-water-related emissions:

- **against noise: e.g. enclosure of motors and blowers.**
- **against emissions into the air: Covering of treatment basins; enclosure of treatment facilities such as automatic rakes, preaeration basins, etc. The waste air must be filtered (e.g. use of compost filter).**
- **treatment of the sewage sludge produced; aerobic stabilisation, anaerobic stabilisation (digestion), drying. Waste air or waste gas quantities produced must be filtered and heat-treated if necessary.**

In addition, the sewage works may have to be landscaped in order to soften its visual impact.

2.3.2.4 Safety measures in sludge disposal

The sewage sludges produced during wastewater treatment in municipal main sewage works and in small domestic sewage works should - after treatment - be recycled in some suitable way. For example, they may be used to fertilise farm land. (see also 2.2.5). The same applies to the contents of cesspits, subject to adequate (secondary) treatment (see 2.2.5.2).

The composition of sewage sludges in terms of their content of heavy metals and non-

degradable, sometimes toxic organic constituents is often a problem. This applies mainly to indirect discharges. Operators of public (central) wastewater disposal systems must then take particular care to ensure that commercial and industrial customers connected to the system discharge wastewater which is harmless both for the operation of the central sewage works and for the use of the sewage sludge on agricultural land (see also Section 3).

One should start from the principle that the sewage sludge is as "good" or as "bad" as the wastewater produced at the source. It is also important to monitor the indirectly discharged wastewater as carefully as the directly discharged wastewater, with particular emphasis on commercial and industrial producers.

It is vital for all community sewerage works initially to identify all commercial and industrial indirect dischargers, where necessary to demand suitable pre-treatment installations for the sites in question and thereafter, at least on a random basis, to monitor the discharge of the relevant plant.

It is also often a good idea to advise indirect dischargers on process-related wastewater management and wastewater avoidance and reduction, so as to avoid emission problems from the outset.

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