Wastewater Treatment in Mountain Regions

OEWAV Recommended Guidelines no. 1

3rd and completely reviewed edition

DRAFT VERSION

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Reviewed by the expert group
« Wastewater Management and Water Protection »

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These recommended guidelines result from honorary teamwork based on both engineering and scientific expertise.

These recommended guidelines are an important but not only source of knowledge for professional solutions.
By its implementation nobody's responsibility concerning own action or accurate application for specific instances becomes withdrawn. Eventual liability by the authors is not given.

We emphasise, that no responsibility is taken for all statements within these recommended guidelines.

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PREFACE

The meaning and importance of efficient water management for water protection and wastewater treatment in the valley are indisputable. The more it becomes an ecological interest – besides fulfilling existing legal liabilities – to reduce human impacts on more or less natural environments and water resources in mountain regions. Besides this general objective, it is a major public concern to prevent any hazards to drinking water resources by point sources originating from wastewater of individual properties in mountain regions.

The solution of wastewater related problems in mountain regions depends on extreme and varying boundary conditions. The type, the construction and the processing of wastewater treatment facilities in mountain regions are affected by e.g. difficult access to certain sites, energy supply, rationing of sites and by challenging load frequencies caused by varying seasonal and weather conditions. This specific situation related to water and waste management in extreme regions motivated the ÖWWV in 1978 to publish the first recommending guidelines reflecting basic difficulties and offering first methods of solution. Technical development within this new specific field effected a revision of this existing guidelines in 1985, taking suggestions for specific solutions into account. Due to elaborated expert knowledge within the field of wastewater treatment in extreme regions ever since and due to the revised emission and immission regulations within the Austrian Water Legislation 1990 (WRG 1990), a second revision of the ÖWWV-Recommended Guidelines no. 1 was required.

Results from the EU Life project “Comparison of Technology, Cost and Environmental Benefit of Wastewater Treatment Plants in Mountainous Areas in the Alps” have been integrated into this newly elaborated guidelines. Within this mentioned project, 15 small wastewater treatment plants have been constructed under different boundary conditions and an operation analysis has been conducted over a time period of four years. The impact of local conditions on the selection of a suitable treatment facility has been monitored. Additionally, the economic and ecological efficiency of the individual plants have been assessed. In this context, we want to express our acknowledgements to both alpine associations DAV and OEAV as well as to the Federal Ministry of Agriculture, Forestry, Environment and Water Management. All these institutions contributed to the broadening of basic knowledge on wastewater treatment in mountain regions by financing relevant research projects.

AUSTRIAN WATER AND WASTE ASSOCIATION

Vienna, April 2000

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1 Objectives and Application

These recommended guidelines were specifically issued to treat wastewater of individual properties in mountain and high mountain regions. However, if no other guidelines exist or if their application seems not reasonable, these guidelines can also be applied for wastewater treatment of scattered housing estates in extreme regions characterised by similar difficult conditions.

These recommended guidelines should in particular summarise the state of the art regarding technical questions within the field of wastewater disposal in mountain regions. These guidelines shall provide user groups of designers, clients and government officials with all essential fundamentals which are necessary for an efficient performance of wastewater disposal projects. Since such planning procedures demand high requirements on a planner's expertise, only agencies with relevant experience should be consulted. However, these guidelines do not aim to answer all technical detailed questions and shall therefore not take the position of a manual for wastewater engineering. In fact the dependence of possible technical solutions on intensively varying regional conditions, which characterise extreme locations, shall be mainly described. Hardly any other field of application within the frame of wastewater engineering is dominated by such specific boundary conditions as the one in mountainous regions.

The legislator is aware of the fact that required emission standards effective for wastewater treatment plants in the valley cannot be transferred to small wastewater treatment plants of individual properties in mountain regions without any adaptations. The effort for meeting the same emission standards as required in the valley would be much higher in extreme regions due to local difficulties or boundary conditions. Therefore, cost and benefit considerations of wastewater treatment plants in mountain regions should always be taken into account in context and should stand in a justifiable relation to each other. With this in mind, the description of fundamental knowledge becomes the main objective of these guidelines in order to solve wastewater problems in mountain regions with maximum ecological efficiency and both reasonable technical and economical effort also meeting legal requirements.

2 Legal Basis and Framework

The construction of wastewater treatment plants and the emission of substances into aquatic systems are liable to various legal regulations. Before starting the design procedure of wastewater treatment plants affecting legal matters have to be considered.

In any case, the construction as well as the operation of wastewater treatment plants require a legal permission following the water law. Minimum requirements for wastewater treatment are defined in relevant regulations. Under certain circumstances these regulations can be facilitated. On the other hand, requirements are more strict concerning measures which endanger water resources within water protection and sanctuary areas as well as for water management framework regulations,

In general an authorisation is required in order to respect not only environmental legislation, which includes different regulations in each state province, but also the building law representing mayors as building authorities. Some cases require legal permission according to trade law, railway law (within the area of railway-, cablecar- or lift-facilities), forestry law (e.g. clearing of woodland) and road legislation.

In specific cases legal permissions, e.g. according to requirements concerning regional planning, or environmental impact assessment etc. might be necessary.

In general the authority of provincial districts (Bezirkshauptmannschaft) respectively embodies the competent authority for all legal matters, except building legislation. In order to prevent cost intensive, incorrect constructing and reconstructing it is suggested to consult the relevant authority or expert (e.g. geology, hydraulic engineering, water ecology, environmental conservation, water management) before performing any planning processes for the procedure(s).

3 Local and Boundary Conditions

3.1 General Introduction

The knowledge on wastewater treatment which has been achieved in the valley cannot be directly transferred into alpine regions, especially high mountain regions. For these regions, solutions considering the extreme boundary conditions have been developed. The following summarises local conditions, which can vary a lot, into boundary conditions specifying the selected procedure, the construction of the treatment plant and especially its operation.

3.2 Site Specific Characteristics – Site Sensibility

The impact on aquatic systems by wastewater from alpine properties depends mainly on the sensibility of a site. On the one hand the possible impact by nutrients and hazardous substances on other properties below as well as the possible contamination of drinking and process water by pathogenic germs have to be considered. As a matter of principal a distinction between two different geological regions have to be made: regions with a **crystalline-silica geology** characterised by a sufficient water provision and a dense soil structure and **sensible karst regions**, which mostly provide groundwater-bodies as drinking water reservoirs and which are characterised by water shortage and rapid water transport into subsurface layers.

If treated wastewater is introduced into a running water, the minimum water discharge during the time of operation of a property has to be considered in order to assess the impact of a set measure on an aquatic system. It can be of advantage for a receiving water to prevent direct wastewater introductions and instead consider the infiltration of treated wastewater and thereby use the purification capacity of the soil body. This natural treatment capacity cannot be accounted without specific verification. Performing infiltration, the determination if and under which conditions the introduction of treated wastewater into the subsurface system is possible. Considering existing subsurface conditions, it has to be assured that the infiltration of wastewater does not interfere with the rights of others.

Environmentally protected areas or national parks show an increased sensibility which is legally regulated. In such areas both the possible qualitative impact on water resources as well as the nutrient input into soils is of relevant significance. Especially the disposal of sludge, effecting a possible local change of vegetation, has to be examined.

All considerations have to integrate existing emitters, as e.g. alpine farming and native nutrient input of catchment areas.

3.3 Altitude

The altitude of a facility influences the temperature of air and soil, wind velocity, snow covering (snow loading including snow freight), duration of vegetation periods, extent of vegetation layer etc. and together with other factors altitude has an impact on wastewater temperature within the treatment plant. Rough climates demand adequate protection- and insulation measures as far as sheltering of the treatment facility. Especially at altitudes more than 2500 m the possibility of permafrost has to be taken into consideration. From this altitude a humus and vegetation layer is absent which complicates the disposal of sludge and compost. Besides altitude the exposition of a site represents an important influence factor.

3.4 Accessibility

The accessibility of a property directly influences the frequency of visitors, the supply and disposal of the facility as well as the construction and operation of the disposal/treatment facilities. If properties are easy to reach, e.g. by truck, an on-site sludge treatment might not be necessary if the sludge can be pumped off and transported into the valley. If alpine huts can only be reached by foot path, small transports depend on the eventual existence of cable cars (payload of 180-250 kg). For substantial supply or disposal services helicopter transports are necessary.

3.5 Operation Periods

Concerning the problem of seasonal operation management of properties the question of the duration of operational breaks and of a possible operation during winter is of interest. During operation in winter the facility has to be reachable despite high amounts of snow which therefore implies that the treatment facility has to be integrated into a building. During longer breaks of operation in most of the cases treatment facilities have to be taken out of action and have to be put back into operation afterwards. At the beginning of a season the treatment facility is supposed to quickly reach its planned treatment efficiency. Concerning short operation breaks (exclusively weekend and stable weather operation) attention has to be paid to load breaks especially when designing biological treatment plants.

3.6 Energy Supply

The energy equipment is of vital importance when choosing a wastewater treatment system. However, a continuously assured and sufficient electrical energy supply primarily enables the application of certain wastewater treatment facilities. The question for a suitable energy supply for wastewater treatment facilities always has to be seen in context with the overall energy supply concept of the alpine property. Nevertheless, the energy supply of the treatment facility should never depend on the energy consumption of the property operation. Existing energy sources should be used after eventual repairs. Regarding a possible existence of an electrical connection to an electrical network or a small power plant, the energy demand of the employed equipment takes a secondary position. An eventual energy surplus can be used to increase wastewater temperatures as well as to improve both sludge stabilisation and treatment efficiency.

The installation of an energy supply using combustion machines in order to exclusively serve the purpose of wastewater treatment has to be prevented. In any case the use of environmentally hazardous operation substances should be restrained and bio-diesels should be used instead. Alternative energy sources can serve as ecologically friendly but investment intensive solutions (especially photovoltaic and wind energy use) which can produce sufficient energy for adapted and energetically optimised treatment systems.

3.7 Existing Treatment Facilities

The existing inventory of wastewater facilities as pipes, settling plants etc. has to be investigated concerning its constructional condition as well as its possible onward application and where appropriate, it should be further used. Existing settling tanks for example can be converted into biological treatment facilities or can at least serve as mechanical treatment stages, sludge storage tanks or equalisation tanks for the biological stage.

3.8 Wastewater Discharge

The maximum hydraulic discharge of wastewater disposal of alpine facilities mainly depends on the existing water supply and on the sanitary equipment (waterless toilets and toilets, washbasins, showers, only cold water supply or also warm water supply within lavatories, number of drain off possibilities). Due to low standards concerning comfort and sanitary equipment, alpine huts show a very low specific water consumption. The water consumption can be classified at 50 l water per population equivalent (PE). In alpine regions the specific wastewater load does not reduce by the same amount as the water consumption which effects strongly increased concentrations. The concentrations of BOD_5, COD, ammonia nitrate (NH_4-N) and total phosphorous (P_{tot}) increase most of the times by a multiple value than those of municipal wastewater treatment plants in the valley.

Water which is used for supply often includes non-buffered storm water and melted water which are both characterised by low alkalinity. However, the carbonate buffer of spring water form crystalline regions is also low. If essential buffer capacities are absent, biological processes within wastewater treatment can be disturbed. A certain increase of hardness of water might be necessary and has to be considered. Therefore, a chemical analysis of the provided freshwater is recommended.

3.9 Organic Load

The organic load of a wastewater treatment plant depends on the type, dimension and capacity utilisation of the affiliated property. As a unit for organic load each population equivalent (PE) has an assigned BOD_5 load of 60 g per day. Due to the special kind of property use and management the specific load, which is determined by the owner, usually is lower and has to be investigated for each user group (see chapter 4.2). Daily loads of single treatment plants vary significantly and are mainly influenced by the weekday, atmospheric conditions and season.

Annual loads of wastewater substances are mainly determined by the type and dimension of the affiliated property, the mean plant utilisation and the annual operation period. The annual load of organic substances is indicated in kg BOD_5 / year and is crucial to the annual quantity of sludge.

4 Fundamentals and Conditions for the Design Process

4.1 General Aspects

Wastewater treatment plants have to be designed respecting regulated legal and local preconditions as well as safety requirements. The dimension has to refer to accepted design guidelines. Concerning some procedures (e.g. fluidised bed-process), institutional intern expertise has to be consulted.
When designing a treatment plant the principals of a reliable and durable technology, stable function as well as an easy maintenance which can be performed by the plant operator anytime, have to be taken into account.

The required **treatment efficiency** is regulated on the part of the authority within the relevant water legislation act of the treatment plant, but should already be co-ordinated with the responsible authority department of the respective provincial government during the design procedure.

The sewerage system implicitly has to be constructed as a **separated sewer system**. Unpolluted water as storm-, melted-, drainage-, hillside drainage- and spring water as well as overflows from drinking water containers must unconditionally be drained separately from wastewater in order to prevent a washout of the treatment plant, a decrease of wastewater temperature and an increase of investment and operation costs. Additionally water which is supplied but not polluted (wells, heat exchange water, de-frosting water) also has to be uncoupled from the sewerage system and has to be drained in and off separately (receiving water, percolation). If possible these amounts of water should be recorded by the arrangement of meters.

The separated drainage of **water from kitchens** by a respectively designed sludge and grease trap is considered state of the art, at least at frequently operated and large properties. If waterless toilets are used the associated greywater has to be collected separately and drained into a possible biological treatment - at best together with the urine from pissoirs as well as the infiltrated water from the waterless toilets.

The possibility of a collective **wastewater treatment of several properties** within a design region has to be considered. Foreseeable new building activity, reconstruction, build up and building extensions within the range of the considered property has to be cleared in detail and respectively taken into account when designing the wastewater treatment facility.

Keeping a constant wastewater temperature by respective measures (e.g. insulation) is of crucial importance for both the drainage and the on-site treatment. The level of temperature gets positively influenced by generous hot-water heating systems as e.g. applied for showers. Sludge and solid waste treatment as well as disposal have to be considered during the design procedure and have to be sufficiently described.

If the design integrates compressors, lower air densities within mountainous regions have to be taken into account.

4.2 Fundamentals of Design

For correct dimensioning of individual treatment facility parts, an exact on-site assessment concerning the most important parameters of wastewater load is necessary before starting the design procedure. Specific loads, which are regulated by the user of a property, depend on the type of the property and especially on the sanitary equipment. For a systematic description of specific loads, a classification of alpine properties is performed (Tab. 1).

Table 1: Wastewater technical classification of alpine properties

Type	Sanitary equipment / Type of property
1	None: bivouac boxes, hunting refuges, preliminary tent camps and camp grounds etc. No usual water supply is provided (transport in buckets etc.), greywater into terrain, waterless toilets
2	Slight: weekend cottage, hunting lodge, alpine huts – self sustaining etc. most of the times no running water in the house, waterless toilets
3	Moderate: refuges offering running water in the kitchen, better equipped weekend cottage, housekeeping room and wash basins, toilets exist, showers just for staff
4	Mean: refuges, simple buildings, all are equipped with sufficient water supply, wash basins, showers, washing machines and dish washers, toilets etc.
5	Good: hotels and restaurants in mountainous areas, permanently occupied military properties and stations, holiday apartments, residential houses etc. generally well equipped including bathroom
6	Very Good: first-class restaurants and hotels, apartment houses with luxury equipment etc. in hotel villages, mountainous holiday resorts etc.

The maximum **wastewater discharge** determines the hydraulic design/dimension of a wastewater treatment plant. The measuring of water consumption using a water meter and a sufficient documentation of the recorded meter values are prerequisites of a sound waste water project. To determine the specific wastewater discharge it is essential to objectively and preferably completely document the daily water consumption and to state the number of day and night time guests over a period of at least one season. Without specific evidence an hydraulic hourly peak up to a quarter of the maximum daily load has to be expected. This hydraulic peak load can be compensated by wastewater technical measures.

Table 2 : Standard values for specific wastewater loads in l per day for preliminary design

Type of building Sanitary equipment	1 none	2 slight	3 moderate	4 mean	5 good	6 very good
Permanent guest	5-15	10-25	25-75	75-120	120-150	150-225
24h guest	5-15	10-20	25-50	50-75	75-150	200-375
Guest for one night	3-15	10-15	20-40	40-60	75-125	125-300
Guest during day time/long stay	2-3	5-10	10-15	10-15	15-25	30-60
Guest during day time/short stay	1-2	2-5	5-10	5-15	10-20	25-50

The application of **water-saving measures** is useful up to a certain degree. Examples for such measures are the use of water-saving fittings, waterless toilets, showers only for staff, washing of clothes exclusively in the valley, use of sleeping bags instead of bed-linens etc.. However, it has to be taken into account that excessive water-savings might cause very high concentrations of ammonia - up to the 10-fold value of municipal

wastewater in the valley – which impact biological processes within the wastewater treatment procedure negatively.
The documentation of the frequency concerning day and night time guests achieves a very good estimation of the **organic load**. Most of the times the calculation of the load – in general COD, BOD_5, and NH_4-N load – is precise enough if the specified load figures are correct. The specific load of individual groups of polluters can be estimated using Table 3. It is useful to complement the calculated determination of the organic load by wastewater measures.

Table 3: Standard values for the specific wastewater load in g BOD_5 per day for preliminary design

Type of building Sanitary equipment	1 none	2 slight	3 moderate	4 mean	5 good	6 very good
Permanent guest	25-30	25-30	55-60	60	60-75	60-90
24h guest	25-30	25-30	55-60	60	60-90	90-150
Guest for one night	20-25	25-25	50-55	55-60	60-90	75-150
Guest during day time/long stay	05-10	10-10	15-20	15-20	15-20	20-30
Guest during day time/short stay	05-05	05-10	10-15	10-15	10-15	10-15

In Austria a general wastewater load of 60g BOD_5, 100 up to 120g COD and 10 up to 12 g N per day and population equivalent (PE_{60}) is assumed. Concerning the building type 0 and 1, the first value stands for the drain off load of an waterless toilet and the second one for the held back load.

The **organic annual load** is important for the design of an eventual sludge storage device and for sludge disposal. Correct information on the mean load of the treatment facility is essential for the estimation of the annual load. The amount of the accumulated sludge depends on the chosen treatment procedure and its quality concerning sludge de-watering.

4.3 Investigations on Various Design Options and Economic Considerations

Both technical and financial possible as well as ecological useful variants concerning the construction and operation should be investigated and compared regarding their advantages and disadvantages. Already during the design procedure of any re-constructions and building up – but especially of new constructions – it has to be examined if the construction of a technical sound wastewater treatment facility does not question the realisation of the whole intention by reasons of costs.

Due to the strong variation in local conditions no standard solution can be performed. First of all the location of wastewater treatment has to be determined. The drain off of wastewater to a central treatment plant in the valley should be aimed for. If this solution demands unacceptable efforts the best ecological, technical and economic on-site treatment variant should be chosen. A removal in tanks or with vehicles should only be considered in exceptional cases.
Within the process of comparing variants, fundamental solution concepts – drain off or on-site treatment – should be discussed and should than be compared with different equivalent and realistically feasible technical possibilities of solutions. In order to perform the comparison of variants in a comprehensive way, all individual types including selection

criteria, process description and treatment efficiency have to be represented. Further, energy demand, energy supply and residues of wastewater treatment (type, amount, treatment and disposal) have to be described. The presentation of costs should clearly and in a sufficiently detailed way include costs of investment and design as well as operation, maintenance, disposal and investigation costs. The comparison of costs should consider capital return and the expected change of the consumer price (e.g. using the LAWA-method).

5 Wastewater Treatment in the Valley

The wastewater can be discharged into the valley, in case a wastewater treatment plant is located within a distance, that allows the treatment of the wastewater from an economical, ecological and business economic point of view. The treatment plant, which receives the wastewater must have enough capacity to secure a good biological treatment of the entire wastewater flow that reaches the plant. A reduction of costs for the ground works for the discharge piping installation can be achieved, if it is carried out simultaneously with other ground works required for electricity or water supply. In the mountainous region it might become necessary that the piping layout differs from the requirements stated in the relevant standard.

The minimum pipe diameter is recommended as 150 mm, this limit can be reduced in case of high slopes or if the wastewater is pre-treated mechanically.

Discontinuous discharge of the wastewater prevents pipe clogging, but it has to be considered that short time subpressure peaks stress the pipe network in this operational mode.

If the wastewater discharge pipe crosses water protection areas, or if the pipe is installed in shallow depth, a pipe-in-pipe construction is recommended. The construction of the pipeline has to consider possible damage due to falling rocks or ground movement. For installation at steep slopes tensile proof pipe connections and pipe mounts are required. In order to avoid unintentional water drainage the pipeline has to be sealed.

In general the installation of the wastewater discharge pipeline has to be carried out at a frost safe depth, for special applications an additional pipeline insulation might become necessary. In permafrost or glacier areas a pipeline heating can be considered, for example by means of hot air discharge into the pipeline. Also discontinuous wastewater discharge prevents freezing up of the pipeline.

The distance between pipeline shafts have to be chosen in order to prevent pipeline damages due to overpressure in case of pipe clogging. The pipeline routing has to consider easy access to the pipeline shaft and sufficient pipe ventilation. In case the pipeline is operated during summer only, a shallow installation depth can be chosen.

The pipeline material has to be extremely durable. The backfill of the pipeline has to be conducted carefully using not too large rocks. The pipeline shaft locations have to be marked or documented sufficiently, so that they can be found easily even in case of snow.

In some cases pressurised discharge networks including pumping stations will have to be chosen for special applications. The pressurised pipeline shall be installed in a way that allows a complete purging of the pipeline after the wastewater discharge.

6 On-Site Wastewater Treatment

6.1 Mechanical Wastewater Treatment

During mechanical wastewater treatment solids are removed from the wastewater. The removal of organic solids leads to a reduction of the organic fraction in the wastewater. Four main principles characterise mechanical wastewater treatment: Flotation, sedimentation, screening and filtration.

Wastewater components, specifically lighter than water (i.e. oil, grease), are removed by means of grease traps. The collected grease has to be disposed separately. Within the grease trap sediments will accumulate. This has to be considered by including an additional sediment sludge volume into the grease trap. For the removal of the sediments, bottom purge valves have proved to work well. In order to prevent odour problems the grease trap has to be sealed. It has to be considered that organic acids occurring within the grease trap may damage the tank material. Grease traps specifically for kitchen wastewater can be installed ahead of other treatment stages.

Mechanical treatment by means of sedimentation is carried out in multi-chamber septic tanks: If the hydraulic retention time is sufficient, solids will accumulate at the bottom of the tank. Also flotation of light wastewater components will occur. The removed solids are collected in a sludge hopper. The advantages of such plants are the robust operation, low maintenance and no electric power demand. Recirculation of effluent into the plant influent allows to maintain the biological activity of the plant during low or no load periods.

A disadvantage of multi-chamber septic tanks are anaerobic degradation processes in the sludge settling zone due to the long hydraulic retention time of the wastewater. These degradation processes lead to solution of wastewater components from the solid into the liquid phase, which decreases the overall removal capacity of the plant. The resolved components also may impair the performance of a following biological treatment stage. Another possible effect of the anaerobic processes are odour problems. Covering up the primary clarifier tanks of a following activated sludge tank has proved to be a good practice to avoid odour problems, the air is removed by a ventilation system and delivered to the aeration system of the activated sludge tanks.

Other static solid separation system, like the ‘filter sack system’, are operating based on the filter principle: The plant is designed with two parallel lanes, only one lane is in operation at a time. When the filter sacks of the active lane are charged up, the other lane is put to operation. The filter sacks should be designed for a continuous operation of one year. The charged up filter sacks are dried and then locally deposited or composted or transported to the valley. The solids removal performance of such system is higher than with mechanical solids separation systems, the wastewater stays fresh and does not foul. No electric energy is required for operation.

Mechanical solid separation systems based on the screening principle are another way of mechanical wastewater treatment. The wastewater passes a screen or sieve, solids up to a certain particle size are retained. The wastewater can be transported further without the interference of fouling processes. The screened wastewater still includes large quantities of small size solids, which has to be considered for the design of a following biological treatment stage. An advantage of these systems is that the retained solids are already dewatered to a certain content. Electrical power supply is required, clogging problems and maintenance demand or important factors for the choice of the proper system.

6.2 Biological Wastewater Treatment

6.2.1 Systematic scheme of applicable treatment procedures

For further degradation of soluble organic wastewater compounds a biological treatment is required. Aerobic and anaerobic processes are state-of-the-art. In high regions, anaerobic processes are difficult to operate, because they require a stable high process temperature. Aerobic processes can be distinguished by the way the bacteria are available for the process: In the activated sludge process, the bacteria are in suspension while in bio-film processes the bacteria are growing on static surfaces.

Figure 1 shows an overview of the great variety of biological treatment processes.

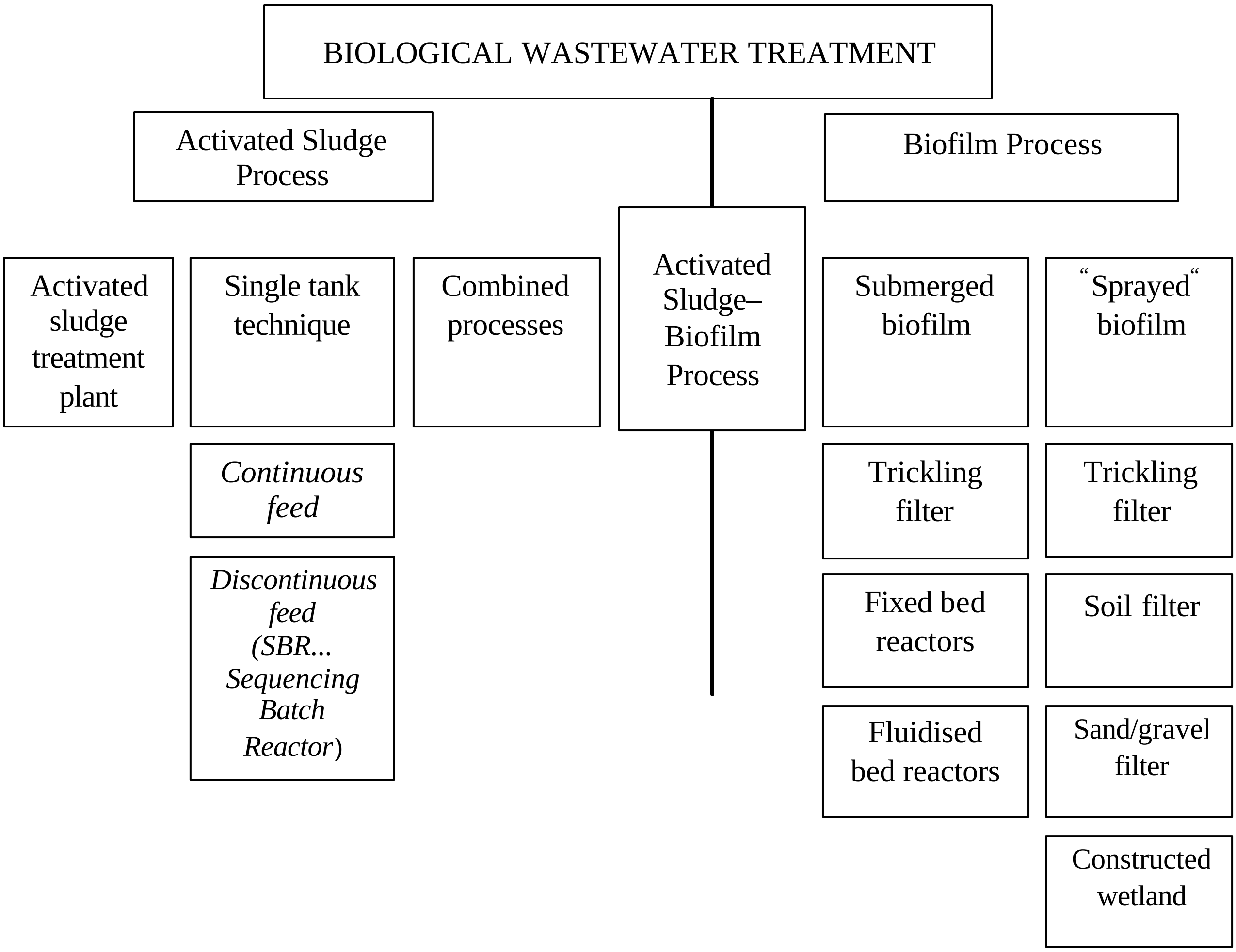

Figure 1: Overview of applicable biological treatment processes

6.2.2 Activated sludge process

The activated sludge process can be implemented in different ways: If a series of tanks is installed, a specific step of the degradation process is carried out in each tank. If only a single tank is installed the different degradation steps take place subsequently.

The widely applied activated sludge process rarely is applied in mountainous regions, since the application boundaries of the process are often in contradiction to constraints such as temperature changes and irregular loading conditions. The process steps like oxidation, reduction (denitrification) and sedimentation are usually carried out in separate tanks along the flow path. Alternatively, all tanks can be integrated in a single compact unit. The activated sludge is recycled within the system from the sedimentation to the biological stage.

The process design has to be carried out according to the same guidelines as for plants in the valley, the choice of the proper sludge age has to consider the low wastewater temperatures. The degradation processes are not inhibited by low temperatures, only the speed of the process is reduced.

For a application of the activated sludge in mountainous regions the following things have to be considered with regard to sludge loss:

- The final clarifier tanks have to be designed based on the maximum hydraulic flow
- The excess sludge withdrawal has to be automated
- Scum removal systems and scum baffles have to be properly designed in order to prevent sludge loss in case denitrification occurs in the final clarifier tanks

The single tank technique is a process type, where the treatment steps are subsequently carried out in the same tank. Since aeration and sedimentation are performed within the same tank, the clean wastewater can be withdrawn only after a minimum sludge settling period. This discontinuous effluent withdrawal is the characteristic of the single tank technique, the wastewater feed to the tank can either be discontinuous or continuos. In the latter case the flow passes the plant by means of gravity, no additional pumping is required. The different operational sequences are controlled automatically. Each operational cycle is made up from the following sequences: Aeration-phase, sedimentation phase and effluent withdrawal phase.

An advantage of the single tank technique is the formation of a floc filter, which sinks to the tank bottom, during the sedimentation phase. This floc filter is very effective in removing small solids from the liquid phase. Furthermore, the single tank technique can be operated very flexible: The length of the aeration phase can be adapted to the actual load.

In opposite, the classical sequencing batch reactor process includes a storage tank in front of the sequencing batch tank. From this tank the SBR-tank is fed discontinuously, which due to the defined feed makes control of the process easier.

Recently, combined systems have been developed where an activated sludge tank is followed by a second tank which is fed discontinuously. In the second tank the sludge sedimentation is performed according to the single tank technique principle.

6.2.3 Biofilm process

Bio-film processes can be separated into two main process implementations: Submerged bio-filters, where the biomass grows on static surfaces submerged in the wastewater and the aeration is carried out by means of electrically driven blowers. The second group are trickling filters, here the wastewater is sprayed on the bio-film the oxygen uptake is directly from the surrounding air.

A submerged bio-filter is a tank that is filled with a material, usually made of plastic, that provides ample surface for growth of a bio-film. The oxygen supply is carried out by aerators, for example fine bubble diffusers at the tank bottom. The wastewater passes through the tank within a certain retention time. The air bubbles rise in the interstices of the filling material supplying oxygen to the bio-film. The tank design (aeration layout, choice of filling material) must secure sufficient oxygen supply and distribution. Fixed bed reactors are a special type of submerged bio-filters, where the filling material is constructed as a single piece. In opposite, 'floating bed filters' have a filling material made of little plastic pieces, which float in the tank. The movement of the filling material in the wastewater/air stream causes an abrasion of excess bio-film from the plastic pieces, which prevents clogging problems. Another type of submerged bio-filters are submerged contact aerators, here the bio-film carrying material is periodically submerged and removed from the wastewater (for example rotating disks). The disks, usually in parallel arrangement, provide a large surface, the bacteria growing in the bio-film are alternately exposed to wastewater and air (oxygen uptake). The movement between the water body and the disk results in a force that leads to abrasion of excess bio-film and thus prevents clogging. The excess bio-film is collected in a following settling tank, sufficient grease removal has to be secured upstream the rotating disks tank.

In a trickling filter the wastewater is continuously sprayed onto the filling material of the filter. The oxygen uptake is directly from the surrounding air. Based on the size and type of filling material a number of trickling filter types are distinguished: sprinkling filters, soil filters, gravel-filters, sand-filters or constructed wetlands. In all cases a filter volume is filled with a material, which provides growth surface for the bio-film and serves as a wastewater filter. The main design parameter is the surface loading rate, which determines the height of the bio-film. It has to be chosen with respect to the available interstice volume. The flushed out excess bio-film is collected in a sludge shaft. In order to prevent clogging of the filter, the wastewater has to be mechanically pre-treated. A sufficient distribution of the wastewater is very important for the performance of the process, the available surface must be utilised as much as possible. Practice has shown that periodic wastewater splashes into the trickling filter yield good results with regard to substrate and oxygen supply of the bio-film. Due to the relatively large interstice volume in a trickling filter the wastewater and air flow do not interfere each other.

In soil filters, gravel- and sand-filter-systems the air is pushed into the filter with the wastewater stream, to improve this effect a splash-wise feeding is advised. The organic load to the plant determines the biomass production and thus the operating period of such systems. Even if all organic material is mineralised, the interstice volume decreases over time and the filter material has to be renewed.

Soil filters are constructed as several layers which are mounted on top of each other. The flow through the filter is in vertical direction oxygen is supplied from air between the layers. San-filter-systems are build as beds and are often planted. In previous years the flow direction in such systems was horizontal, which often lead to oxygen limitation. Nowadays step-feed systems are implemented and the flow direction is vertical. The flow through the system should be by gravity, reducing the need for pumping for a possible recirculation only.

Planted soil filters gain from the dispersing effect of roots, additionally, the plants contribute to the overall degradation performance of the filter. The planted filter system should be protected by a fence, especially in pasture area. The applied plants should be typical for the area, if fast growing plants are used it might become necessary to remove some plants periodically.

The advantage of trickling filter systems are the simple, low energy operation. Problems could develop from discontinuous operation, cold temperatures or heavy rainfalls. Monitoring of the performance of such systems is rather complicated.

6.2.4 Other specific treatment procedures

In bio-film – activated sludge plants the activated sludge tank is partially filled with filter material. The bacteria grow as bio-film on the filter surface as well as in suspension. The interstice has to be large enough to prevent sludge settling. Excess sludge has to be withdrawn periodically.

Aerated and non-aerated lagoons can be used for biological treatment of mechanically pre-treated wastewater. Due to the rather large space demand of such systems, their application in mountainous regions is limited. Polishing lagoons can be used for hydraulic equalisation at single tank systems, or generally to reduce the suspended solids content of the treatment system effluent.

Anaerobic treatment processes, due to the required high process temperatures, are in general not suitable for application in mountainous regions. The effluent of such processes can lead to odour problems and has high ammonium concentrations. Anaerobic treatment can be considered for excess sludge treatment.

6.3 Chemical - physical Wastewater Treatment

In mountainous regions the chemical wastewater treatment is usually used as an additional treatment stage of a biological treatment plant. Application fields are the addition of chemicals for improving the sludge settling properties and chemical stages for treatment of peak loads. Possible chemical processes are precipitation, flocculation and chemical oxidation, which also serves for germ reduction.

These chemical processes require an automatic operation and a close supervision of the process. The chemicals have to be dosed automatically. The required reaction- and settling volumes are provided in the biological treatment stage.

6.4 Germ reduction

For special applications (seeping in karst regions, treated wastewater recycling, discharge of the treated wastewater to recreational areas) a germ reduction is required. Extensive germ reduction is can be achieved by means of ozone, hydrogen peroxide or UV-radiation. For treated wastewater seeping or discharge to recreational areas a germ reduction by means of a planted filter is sufficient. This filter is installed at the effluent of a biological stage. Chemical disinfection agents are not suitable for application in mountainous regions, due to their long term effect on the ecosystem. Furthermore, authorities usually do not approve the application of such chemicals.

6.5 Alternative solutions for uncritical cases

If the wastewater quantity to be treated is small and discontinuous only, only simple means for the treatment are required. In the following a few possible solutions are mentioned:

Sealed cesspool tanks can be applied if measures are taken to reduce the water consumption, for example the installation of waterless toilets. The collected wastewater and faeces are transported away by cesspool trucks.

For the treatment of grey water simple constructed wetlands or gravel filters without internal recirculation are a possible solution. These systems operate without external power supply. Also supernatant from waterless toilets or urea can be treated together with the grey water.

Chemical toilets can be applied in objects, which are used sporadically only. These toilets are filled with a septic liquid, which inhibits fouling of the received faeces and wastewater. The contents of chemical toilets have to be treated in a local wastewater treatment plant.

Waterless toilets are available in different sizes. They can be used in shelters and alike. A separate installation outside the object including a settling tank is possible.

In case the solids from a waterless toilet are to be composted, compost toilets can be applied, which are available as ready-to-use systems. In such systems the liquid and solid phase is separated, the solid phase is composted together with added structural material.

7 Disposal of Separated Wastewater Contents (Sludge)

7.1 Possibilities of Sludge Disposal

Wastewater treatment and sludge treatment are to be considered as a combined unit. Possibilities of sludge treatment and disposal directly influence the choice of the proper wastewater treatment system and vice versa. Other influencing factors are transport possibilities and regulations concerning sludge disposal. Already at the start of the planning phase of a wastewater treatment project local authorities should be contacted in order to agree on a sludge disposal concept.

Depending on the three influencing factors wastewater treatment, mode of transport and legal requirements there are different solutions for the sludge problem (Figure 2):

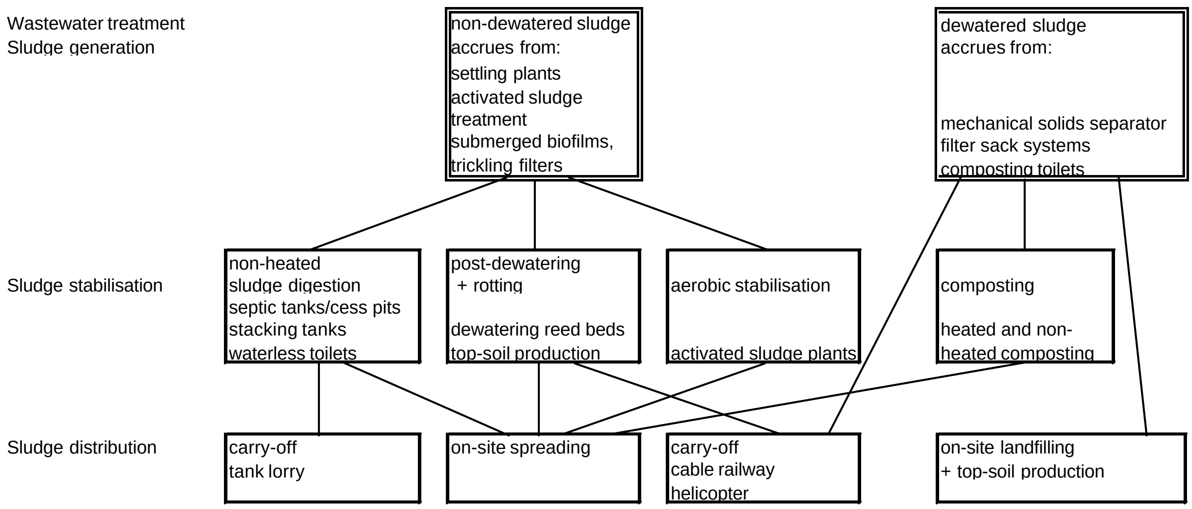

Figure 2: Solutions for the sludge problem

Wastewater contents can accrue as primary sludge from grease, bottom deposit sludges, leftover food, toilet paper, feces, toiletries etc. and as secondary sludge from biological treatment. In addition, filter cakes, screenings or residues from waterless toilet can be generated. Principally, the lack of problematic wastewater contents such as heavy metals, toxic substances etc. qualify the sludges that are generated in high mountain regions for on site spreading. Slowly putrescible material such as toiletries containing synthetics are to be collected separately and require measures such as placing a sufficient number of rubbish bins at public disposal and setting up signs.

Generally, one should distinguish between the two sludge qualities represented by primary sludge from mechanical treatment on the one hand and secondary sludge from biological treatment on the other hand. Their consistencies can be different (e.g. dewatered primary sludge or screenings and thickened secondary sludge) and there can be different legal requirements towards sludge distribution.

In high mountain regions enhanced stabilisation will not be thrived for in most cases. However, it will be necessary to have a sufficient storage tank volume - independent on the degree of stabilisation and on whether the sludge is transported into the valley or treated and spread on site.

7.2 Sludge Stabilisation

Non-heated sludge digestion is a common and economic process in high mountain regions. In most cases multi-chamber septic tanks are realised. As mentioned above, they concurrently operate as settling and storage tanks. In cess pits and waterless toilets sludge digestion will also take place. In most cases however, actual digestion temperature and retention time will allow for partial stabilisation only. Practical experience shows, that the partially stabilised sludge is suitable for both transport into the valley and on-site spreading.

If the sludge has been sufficiently dewatered it can be composted. **Composting**, though, requires a considerable expenditure of human labour. A light consistency facilitating oxygen transfer is a prerequisite for successful composting. It is obtained by adding material such as straw or grape mark that absorbs humidity and increases the throughput of air. If technically feasible, the composting process can be accelerated by periodically turning over the sludge. The better the process is looked after, the less odour will develop. Adding material like hay dust which has an intensive flavour itself, can help minimise offensive smells. In regions of high altitude and low ambient temperature suitable conversion rates can only be achieved when the process is supported by heating. If there is a lack of energy a hot-air radiation heating system together with solar panels could be used, thus providing an energy source which is also available out of season.

Aerobic stabilisation can be performed in an activated sludge plant. This process requires to mechanically supply oxygen. Thus, aerobic stabilisation of the entire excess sludge (including primary sludge) is energy consuming. Additionally, it calls for extra reactor volume. One should therefore attempt to use energy surplus during low and off season sludge stabilisation. In principal, this will also suffice for partial stabilisation only.

In case of minor and continuous sludge production thin layers of partially stabilised excess sludge from wastewater treatment can be spread on sheltered **dewatering reed beds**. Evenly distribution of the sludge on the reed bed and reliable ventilation of the latter should be thrived for. As an alternative, **top-soil production plants** can be constructed. Their purpose is to dewater the sludges from small wastewater treatment plants and produce top-soil. Here, very thin layers of aerobically or anaerobically pre-stabilised sludge are spread periodically on the surface of top-soil production tanks. The latter should be well overgrown with reeds to form a dense mat of rhizomes. The dimensions of the dewatering reed bed depend on the final quality the sludge should reach. If feasible, a draining system collecting seepage and precipitation waters should be located on the tank bottom. The collected water can then be reprocessed.

Chemical conditioning is performed by adding material like slaked lime. Quicklime is used in special cases only. However, as a side effect, quicklime addition yields sludge hygienisation.

Pyrolysis and incineration are counted among the **thermal sludge treatment** techniques. Due to the high costs and the sophisticated operation they are rarely applied in high mountain regions. Or, they are used when huge buildings with a respective number of employees have to be supplied with heat. Then, post-incineration of flue or smoulder gas is a reliable means for odour control.

Distribution of sludge and solid waste

If the transport routes are short and unproblematic or if on-site spreading is prohibited **transportation of the sludge to the nearest wastewater treatment plant in the valley** is recommendable or required, respectively. If the property has an access road the transportation weight is of minor importance. The sludge can then just be sedimented in a primary settler or a storage tank and does not have to be further dewatered. However, if the sludge has to be transported by means of a helicopter or cable railway, weight minimisation – namely dewatering – is a prerequisite. In case of a three-chamber treatment plant this can be performed in a dewatering reed bed, for instance. It makes more sense, though, to use other mechanical waste water treatment facilities which allow to dewater the sludge at the time of its production. Additionally, the principal distinction has to be made whether the untreated primary sludge alone or whether also the activated sludge of a biological stage has to be delivered.

On site spreading of the sludge should only be performed in non-sensitive areas and requires approval by authority. Prior to spreading the sludge must be homogenised. Spreading is restricted to defined areas which must not be at close range of waters. It should be performed on re-vegetation areas, preferentially.

If rather compact waste products are generated and transport is extraordinarily difficult, there is the possibility of on site top-soil production. It is performed in specially dedicated rather small areas which ought to have both a filter and a drainage layer and which should be effectively delimited from the surroundings. In order to accelerate the process of top-soil production the waste product has to be mixed with humus and structure supporting material and has to be covered.

Composted waste products can also be spread on dedicated small spots – favourably on re-vegetation areas.

8 Realisation

8.1 Bidding

In high mountain regions the type of bidding invitation is essential. Construction projects that shall be partly financed through the “Umweltförderungsgesetz” (Environmental Promotion Law) have to be performed both in accordance with the allocation rules and the “Regelblatt für Vergaben im Bereich der Siedlungswasserwirtschaft” (Guideline for Allocations in the Field of Sanitary Engineering). The chosen type of bidding invitation already determines both allocation and construction development. In particular, three types of bidding invitations can be distinguished:

When the invitation to bid asks for a unit-price offer the single trades for the erection of the waste water treatment plant (such as builder’s work, mechanical outfit and electronic equipment etc.) are bid separately. As the bidding documents already contain a detailed description of the chosen treatment process and its performance the proposals are mainly revised by applying factual and financial criteria. The effort for construction co-ordination and management is enormous and requires considerable experience of both the designer and the site manager. Travel time, transport and co-ordination represent essential expense factors when building in high mountain regions.

When the invitation to bid asks for a lump-sum offer the planned construction is carried out by a general contractor who hands over a turnkey wastewater treatment plant. The specifications have to thoroughly define the quality and quantity of each item. During the development of the construction the designer or, respectively, the site manager is responsible to control the compliance of each item with the quality that has been defined in the specifications. The building owner’s or the designer’s effort for co-ordination is minor to his effort in case of a unit-price invitation to bid. Alike in this case, the treatment process is already determined when the invitation to bid is published.

When the invitation to bid asks for a functional offer the designer issues a programme where certain criteria that must be met are laid down. It is essential to exactly specify the purpose of the future plant and to list the boundary conditions. In his proposal, the bidder has to offer a turnkey plant. Different from the above invitations to bid the treatment process is chosen by the bidder. He must also precisely define criteria that specify the performance of this plant. In addition to this offer, the proposal may also contain an offer for future plant operation. A functional invitation to bid calls for a highly experienced designer. When verifying whether the criteria he has issued are met he must be able to go into every detail of the proposals. In the contract the tasks to fulfil and the required quality have to be described very precisely.

8.2 Construction Management

Boundary conditions such as travel time, infrastructure, energy supply, temperature, weather, etc. are characteristic for high mountain regions and limit the construction time. This calls for a meticulous design and site management including a precise inventory control and detailed construction plans. In order to minimise expense factors like travel time and transport, efficient site management necessitates provident design, organisation and logistic. Hence it is essential that the building owner or an authorised person adequately survey the construction works.

Leak tests of tanks and pipes have to be checked with simple methods which should be as similar as possible to the methods laid down in the respective technical standards.

Prior to any excavation alpine plant and grass sods should be removed carefully and stored separately from the remaining excavation material, thus allowing for re-cultivation after the construction works have been finished.

9 Operation, Maintenance and Monitoring

9.1 General Introduction

Wastewater treatment plants can fully serve the purpose only if the are operated skilfully and diligently. Hence, they must both be maintained and monitored. Maintenance of a wastewater treatment plant, and in particular maintenance of its mechanical equipment, comprises routine work and adjustment of minor failures. Monitoring can be subdivided into the following fields:

- plant operation monitoring
- internal monitoring
- outside monitoring

Plant operation monitoring comprises both seizing and documenting of major operational parameters. The aim is to secure an undisturbed and economic wastewater treatment plant operation which is in compliance with official notifications in the long run.

Internal monitoring denotes the control of the wastewater composition by either the treatment plant operator himself or by an authorised person.

Outside monitoring stands for the control of the wastewater composition by the competent supervisory authority. Additionally, the plant operator can put an expert or a qualified institute or firm in charge of outside monitoring.

9.2 Requirements for plants with a design load > 50 PE_{60} according to the "1. Abwasseremissionsverordnung für kommunales Abwasser" (Austrian "1st Decree on Emission Standards for Municipal Wastewater)

Generally, the "Wasserberechtigte" (= person who has obtained a legal permit for a certain use of water) or one of his assistants perform maintenance, plant operation monitoring and internal monitoring. This calls for a sound training. The ÖWAV (Austrian Water and Waste Association) has published several guidelines on maintenance, plant operation monitoring and internal monitoring (see appendix).

Outside monitoring, though, is principally performed by someone the plant operator has appointed (experts or qualified institutes or firms). However, this is only possible if the competent authority doesn't perform outside monitoring itself. The principal legal requirements towards internal and outside monitoring are contained in either the "1.Abwasseremissionsverordnung für kommunales Abwasser" or in the special emission decrees that have been issued for several industrial sectors.

9.3 Requirements for plants with a design load <= 50 PE_{60}

Momentarily, there is only a draft version of the relevant decree on emission standards. Presumably, the principal requirements towards maintenance, plant operation monitoring and internal monitoring will be quite similar to those described in Chapter 9.2.

9.4 Requirements for plants of the category of the "Extremlagenverordnung" ("3. Abwasseremissionsverordnung für kommunales Abwasser") (=Austrian "3rd Decree on Emission Standards for Municipal Wastewater which is effective in extreme regions)

Here, the treatment plant operator or his representative is not obliged to proof compliance with the emission standards by carrying out measurements and analyses in the course of internal monitoring. In spite of that, the following demands must be met:

1. The competent authority must approve operating instructions for the whole waste water treatment
2. Operation and maintenance must follow these instructions
3. Maintenance of the entire wastewater treatment plant must be performed by an experienced person and must be based on an officially approved agreement or service contract
4. A diary must be kept recording the number of guests, water consumption, operation and maintenance
5. Within the scope of outside monitoring the "Wasserberechtigte" must assign an expert or a qualified institution or firm at least once a year to prove that the emission standards are met
6. Annually, a report on items 4 and 5 must be forwarded to the competent authority.

The praxis has shown that it is effective and economically advantageous to assign one contractor to perform both maintenance and measurements within the scope of outside monitoring. The operating instructions and the service contracts must contain precise provisions towards sludge and solid waste distribution.

10 Further Measures of Water Conservation

Mineral oils represent one of the most important environmental perils towards water. In high mountain regions they are primarily used for transportation (snow cats, forest vehicles, cable railways, etc.), electricity generating sets and heating systems. Stacking of mineral oil products beyond 1000 l has to basically comply with the water conservation guidelines that regulate the stacking of liquid fuels. It is allowed to adapt the guidelines to the specific local situation in high mountain regions. Similarly, the relevant federal and provincial legal acts have to be fulfilled. Waste oil has to be collected, transported and disposed of harmlessly in compliance with the legal requirements. Oil binding agents have to be available. If possible, mineral oils like diesel fuel should be substituted by bio-diesels (e.g. rape seed-methyl-ester).

In accordance with an integrated environmental view orderly disposal of solid and liquid waste from animal-keeping has to be provided, too.

Properties in high mountain regions mainly produce domestic or quasi-domestic solid waste which has to be disposed of (packaging material, tins, bottles, glass, etc.). On site, both waste prevention and separation should be performed. Normally, the solid waste is to be transported into the valley for further treatment and disposal. Relevant measures for separation, intermediate storage and compaction and mechanical installations for the transport have to be provided. With the exception of composted waste, deposition of solid waste in high mountain regions does not comply with the idea of water protection. For organic domestic waste composting the statements of chapter 7.2 are applicable.

11 Public Financing in Austria

At present, financial promotion by public funds is regulated both on a national and a provincial level. Each province has its own promotion guidelines, the national and the provincial financial promotion depending on each other. Independent on whether applying for national or for provincial financial promotion the institution to turn to is the “Amt der Landesregierung” (= office of the provincial government) which has the jurisdiction over the respective region.

The documents to hand in must be drawn up by an authorised person. It is important that an application for financial promotion has to be presented at the competent “Amt der Landesregierung” prior to beginning the construction works.

12 Information on Legal Fundamentals and Literature

12.1 Legal Basis

Wasserechtsgesetz 1959, BGBl. Nr. 215/1959 i.d.g.F.

Allgemeine Abwasseremissionsverordnung, BGBl. Nr. 186/1996 i.d.g.F.

1. Abwasseremissionsverordnung für kommunales Abwasser (1. AEV für kommunales Abwasser), BGBl. Nr. 210/1996 i.d.g.F.

3. Abwasseremissionsverordnung für kommunales Abwasser (3. AEV für kommunales Abwasser), BGBl. Nr. 869/1993 i.d.g.F.

Indirekteinleiterverordnung, BGBl. Nr. 74/1997 i.d.g.F.

Abfallwirtschaftsgesetz, BGBl. Nr. 325/1990 i.d.g.F.

Umweltstrafrecht : Strafrechtsänderungsgesetz, BGBl. Nr. 605/1987 i.d.g.F.

Umweltinformationsgesetz, BGBl. Nr. 495/1993 i.d.g.F.

ArbeitnehmerInnenschutzgesetz (AschG), BGBl Nr. 450/1994 i.d.g.F.

Allgemeine Arbeitnehmerschutzverordnung (AAV), BGBl. Nr. 218/1983 i.d.g.F.

Bauarbeiterschutzverordnung (Bau V), BGBl. Nr. 340/1994 i.d.g.F.

Baukoordinationsgesetz (BauKG), BGBl. Nr. 37/1999 i.d.g.F. Machinen-Sicherheits Verordnung (MSV), BGBl. Nr. 306/1994 i.d.g.F.

12.2 Standards, Guidelines and Leaflets of the Austrian Water and Waste Association (OEWAV)

12.2.1 OEWAV Recommended Guidelines

6	Fremdüberwachung von biologischen Abwasserreinigungsanlagen. Teil 1 : Fremdüberwachung gemäß 1. AEV für kommunales Abwasser. Wien, 1998.
6	Fremdüberwachung von biologischen Abwasserreinigungsanlagen. Teil 2 : Gesamtprüfung. Wien, 2000.
7	Mindestausrüstung für die Eigenüberwachung und Betriebsüberwachung biologischer Abwasserreinigungsanlagen. Wien, 1998.
13	Betriebsprotokolle für Abwasserreinigungsanlagen. Wien, 1995.
	Beiblatt zum ÖWAV Regelblatt 13 Betriebsprotokolle für Abwasserreinigungsanlagen. Wien, 1998

15 Der Klärfacharbeiter – Berufsbild, Ausbildungsplan und Prüfungsordnung. Wien, 1997.

17 Landwirtschaftliche Verwertung von Klärschlämmen – Empfehlungen für Betreiber von Abwasserreinigungsanlagen. Wien, 1984.

201 Leitlinie für den Nützung und den Schutz von Karstwasservorkommen für Trinkwasserzwecke. Wien, 1994.

12.2.2 OEWAV Recommendations (Arbeitsbehelfe)

10 Betrieb- und Betreuungsgemeinschaften in der Abwasserentsorgung. 1993.

14 Eigen- und Betriebsüberwachung von biologischen Abwasserreinigungsanlagen (>50 EW), 2. vollständig überarbeitete Auflage. Wien, 1998.

12.2.3 OEWAV Leaflets

Landwirtschaft und Grundwasserschutz. 1981

12.3 Standards

12.3.1 ÖNORMEN I.D.G.F. (AUSTRIAN STANDARDS)

B 2502-1 Kleinkläranlagen (Hausanlagen) für Anlagen bis 50 EW – Anwendung, Bemessung, Bau und Betrieb)

B 2502-2 Kleinkläranlagen für 51 bis 500 EW

B 2504 Schächte für Entwässerungsanlagen

B 2505 Bepflanzte Bodenfilter (Pflanzenkläranlagen) – Anwendung, Bemessung, Bau und Betrieb

B 5103 Fettabscheideranlagen

prEN 12255-4 Abwasserbehandlungsanlagen – Teil 4 : Vorklärung

EN 12255-5 Abwasserbehandlungsanlagen – Teil 5 : Abwasserteiche (

prEN 12255-6 Abwasserbehandlungsanlagen – Teil 6 : Belebungsverfahren

prEN 12255-8 Abwasserbehandlungsanlagen – Teil 8 :Schlammbehandlung und – deponierung)

prEN12555-10 Abwasserbehandlungsanlagen – Teil 10 : Sicherheitstechnische Baugrundsätze

prEN 12566-1 Kleinkläranlagen für <50 EW – Teil 1 : Werkmäßig hergestellte Faulgruben

prEN 12566-3 Kleinkläranlagen für bis zu 50 EW – Teil 3: Vorgefertigte und/oder vor Ort montierte Behandlungsanlage für häusliches Schmutzwasser

12.4 ATV Guidelines Wastewater – Waste (Guidelines of the German Association for Water, Wastewater and Waste)

12.4.1 ATV Recommendations (Arbeitsbehelfe)

A122 Grundsätze für Bemessung, Bau und Betrieb von Kleinkläranlagen mit aerober biologischer Reinigungsstufe für Anschlußwerte zwischen 50 und 500 EW. 1991.

12.4.2 ATV Leaflets

M210 Belebungsanlagen mit Aufstaubetrieb, 1997.