

## CURRENT STATE AND MODERN APPROACHES OF WASTEWATER TREATMENT IN GERMANY

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### ABSTRACT

In the 1980's further nutrient removal was carried out at larger wastewater treatment plants in Germany based on the removal of settleable suspended solids and the reduction of the organic carbon load. For sensitive areas even more stringent treatment standards can be required. The applied techniques, of which examples will be given, have not only to fulfill the advanced standards, but also have to minimize the energy impact and reduce the disposals. Corresponding to the sludge concept, a sludge digester is installed in many plants to obtain biogas used for heating and as an additional energy supply. More than 90% of the inhabitants are connected to the public sewer system. For rural areas, decentralized treatment concepts and the upgrading of individual sewage treatment plants are preferred. In all areas, possibilities of rainwater percolation and stormwater treatment are used to restrict the amount of sewage. The general administrative approach is to focus on the receiving waters. Beside the standard requirements of the law, further demands will depend on the hydrographical situation of the river basin area to fit the investments on the demands of the specific environment.

### KEYWORDS

General wastewater treatment, nutrient removal, rural areas, stormwater treatment, use of biogas, river basin management

### INTRODUCTION

For a long time a mechanical and biological treatment for reducing the organic carbon load was state of the art in Germany. For example, proved systems like an Imhoff tank in combination with a trickling filter were sufficient enough to fulfill the demands and had a low energy demand. The mechanical step consisted of a coarse screen and a preliminary sedimentation tank. In this tank, the sedimented sludge sank down to a connected digester below and was digested for months. Overlapping partition walls kept the produced gas away from the continuous wastewater flow through the sedimentation tank. A high loaded trickling filter was used for carbon reduction and the excess sludge was collected in an upflow settling tank. The collected sludge was also treated in the Imhoff tank and used at farmsides.

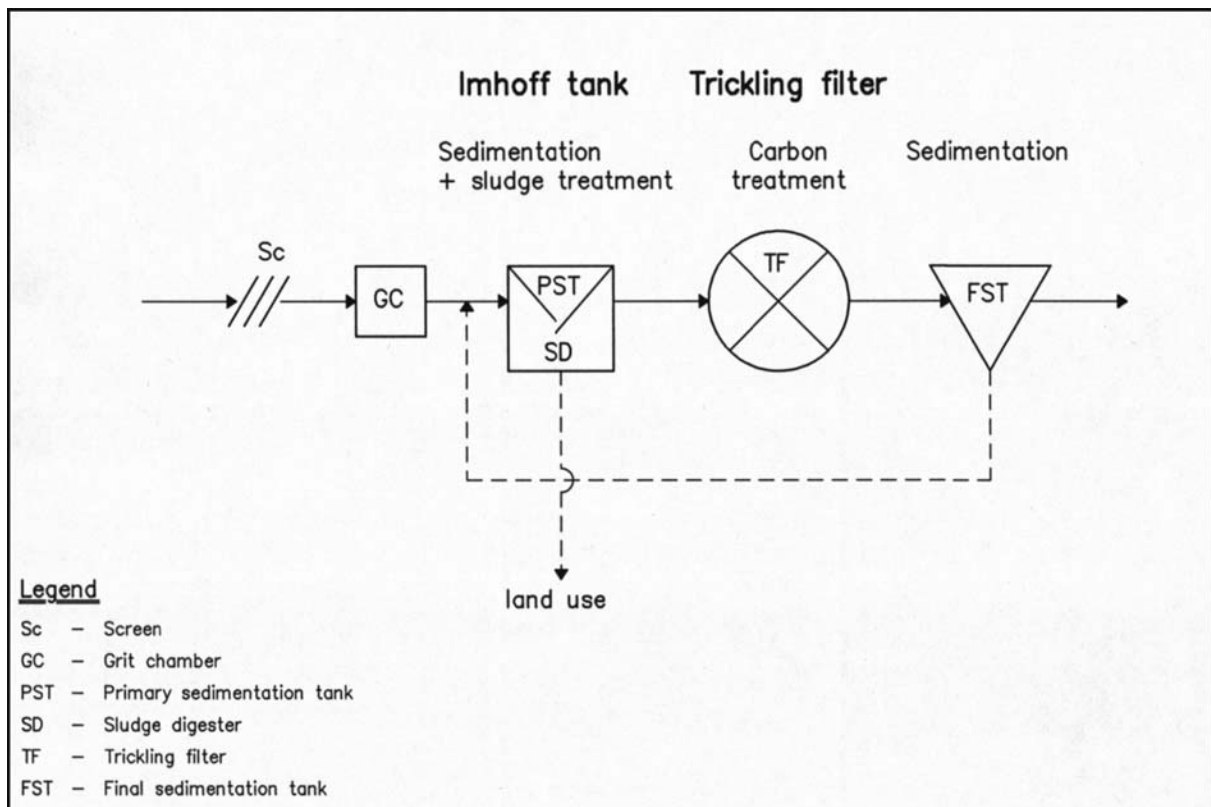


Figure 1: Typical treatment plant for carbon treatment and sludge stabilization in earlier time

But the total wastewater load was rising and when serious eutrophication occurred in rivers and lakes, the government decided to demand higher treatment standards for further nutrient removal by law. To reach this goal, most of the plants were upgraded and extended. Nowadays, most of the 10 Mio m<sup>3</sup> of wastewater in Germany is treated in plants with biological nutrient removal (ATV '96).

The contents of typical European wastewater are listed in table 1 (ATV '00), corresponding to the eating habits. Municipal wastewater in Germany contains used drinking water of about 130 l per inhabitant and day, sewer infiltration water and sometimes stormwater. Long-term control values in the effluent of the treatment plant are also listed in table 1, they depend on the size of the plant.

Table 1: Wastewater contents of 1 population equivalent (PE) and control values of the treated wastewater

Parameter	Daily load (g/ PE * d)	Control values (mg/l)
COD	120	60 – 150
BOD5	60	10 – 40
SS	70	5 – 20
N	11	10 – 18 (or 70% red.)
P	1.8	0.5 – 2

The reuse of sewage sludge is depending on its contents, like heavy metals and adsorbable organic halogen compounds. The allowed contents are given by a special sludge regulation. Often the sludge contents exceed the allowed levels. Problems are mainly caused by copper and zinc. Those metals are used in pipes and gutters and appear in form of non-point source pollution. Only a smaller part of the sewage sludge can be used in landside any more, most of it gets dumped (BGW '97).

Some of the steps to reduce the environmental damage are: increasing the wastewater treatment quality in big and small plants, pre-treatment of industrial wastewater, actions for water saving and water reuse, storage and treatment of combined water as well as the reduction of stormwater discharge.

## SEWAGE TREATMENT

The first treatment is applied by automatically cleaned fine screens, sometimes in combination with a coarse screen. Often used spiral screens are pushing the screening inside up and dewater it at the same time. In most cases, the carbon is limiting the rate of biological nitrogen elimination. Therefore the screenings can be stirred to wash out the carbon inside. New developments use high powered bale presses to get a better reduction of the volume and increase the dry solid matter. Afterwards the screenings get damped or burned together with domestic garbage. Another approach is to reduce the organic compounds by composting the screenings. Clogging constituents have to be removed first by using fine screens. Most of the organic material is lost within a composting time of more than 5 weeks and temperatures of more than 70° C.

To separate the grid, aerated grid and grease chambers are often used. The aeration causes a continuous circulation that prevents the organic material from settling. A constant minimum velocity can be obtained, even when the hydraulic load gets very low. New developments try to improve the separation of organic and mineralic material by washing the grid after removing. Composting of the grid is also a new attachment for reducing the organic matter.

Sedimentation with a retention time of up to 2 hours can reduce the total carbon load by one third. A long sedimentation is applied, if the carbon is not needed for further nutrient removal. If the carbon source is needed for denitrification, pre-sedimentation is losing its importance. Sedimentation time then gets reduced to about 20 minutes. For smaller plants without a separate sludge treatment, the settleable suspended solids get treated together with the activated sludge by a long time aeration.

For the biological stage as the main part of the treatment plant, the activated sludge system showed the best possibilities to implement various processes for nutrient removal. The most used activated sludge process in Germany is the pre-denitrification in mixed tank reactors. For activated sludge tanks with circulating flow, the simultaneous denitrification is preferred. In recent years the step-feed denitrification (Werner '98) and sequencing batch reactors are also applied frequently.

A biological phosphorus elimination can be achieved by integrating an anaerobic reactor within the process for nitrogen elimination. Mostly it is supported by simultaneous chemical precipitation to provide sufficient elimination rates even in changing influent and weather conditions. Phosphorus precipitation can also be applied in plants without nitrogen elimination.

In trickling filters, the implementation of denitrification and internal recirculation is difficult. Therefore new trickling filters get applied more seldom, but existing trickling filters are often integrated within the extension of a plant. For nitrification, trickling filters still have a good performance. An application for a new trickling filter was given for a plant with post-denitrification, where the water gets nitrified separately (Buß et al. '00). Other fixed film reactors used for the main biological treatment are biofilters. Applied in younger time, they combine nitrification, denitrification, internal recirculation and a filtration in small reactors. New developments try to optimize the aeration control to restrict the recirculated oxygen.

Multiple stage treatment is applied, if the efficiency of a process is not capable enough to fulfill the demands. For example, a filtration can bring a further reduction after a conventional biological treatment stage. A 2-stage-filter can integrate different process-steps by using an aerated first stage for nitrification and an unaerated sandfilter as second stage. Addition of external carbon and precipitants can implement further denitrification and a contact filtration for phosphorus removal (Günter '96).

Most of the plants in Germany were extended, but there are also examples for totally renewed plants and other treatment processes applied in the biological stage. In figure 2 an example for the integration of existing reactors is given.

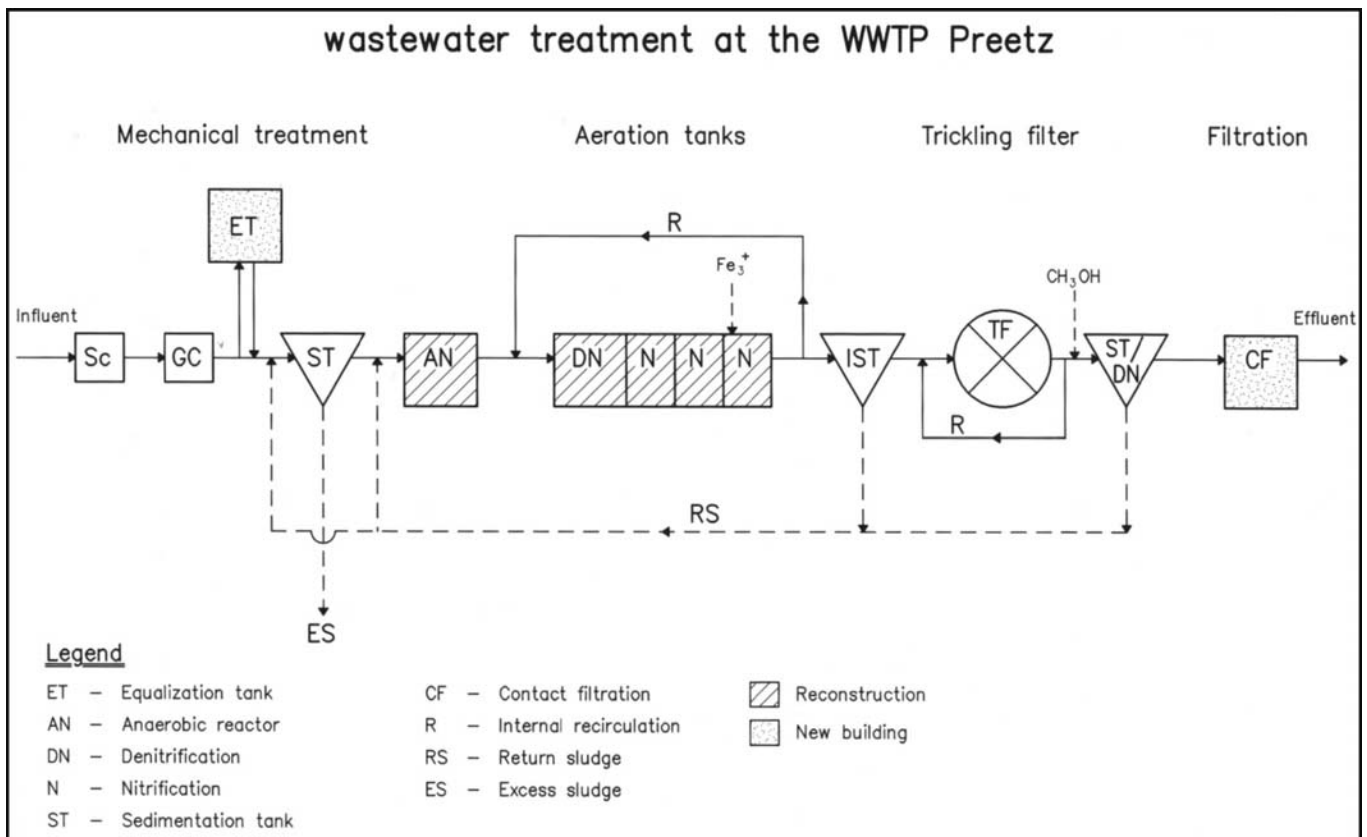


Figure 2: Present example for an extended treatment plant for nutrient removal (Buß et al. '94)

When the effluent outlet of the plant is close to a swimming area, a sterilization of the treated wastewater can be demanded. Therefore, a treatment with UV-lights is sometimes applied.

## SLUDGE TREATMENT

The process for sludge treatment is chosen with regard to the disposal goal. In most cases it includes a stabilization, thickening, dewatering and for reuse a hygienization by adding lime. In smaller activated sludge systems, an aerobic stabilization takes place within the aeration tank by adapting a long sludge age. In plants with more than 20.000 PE, a separate anaerobic stabilization in a heated digester can be applied. The suspended organic matter is reduced and the biogas is used to produce energy. The biogas gets cleaned and buffered in a gas tank before using it in gas engines to produce electricity and heat. The total mass of the sludge gets reduced to one third, what also brings down the costs of the sludge disposal. In some plants, full scale windcraft and solar power addition ist tested to supply the energy demand (Buß et al. '98).

For sludge dewatering, centrifuges, belt type and filter presses are used. A further sludge drying process can be applied, if the sludge is reused and needs to be stored for longer time. In case of short termed reuse or sludge disposal, a drying process is not necessary. In all cases, the possibility of sludge reuse is depending on the tested amount of sludge contents according to the sludge regulation.

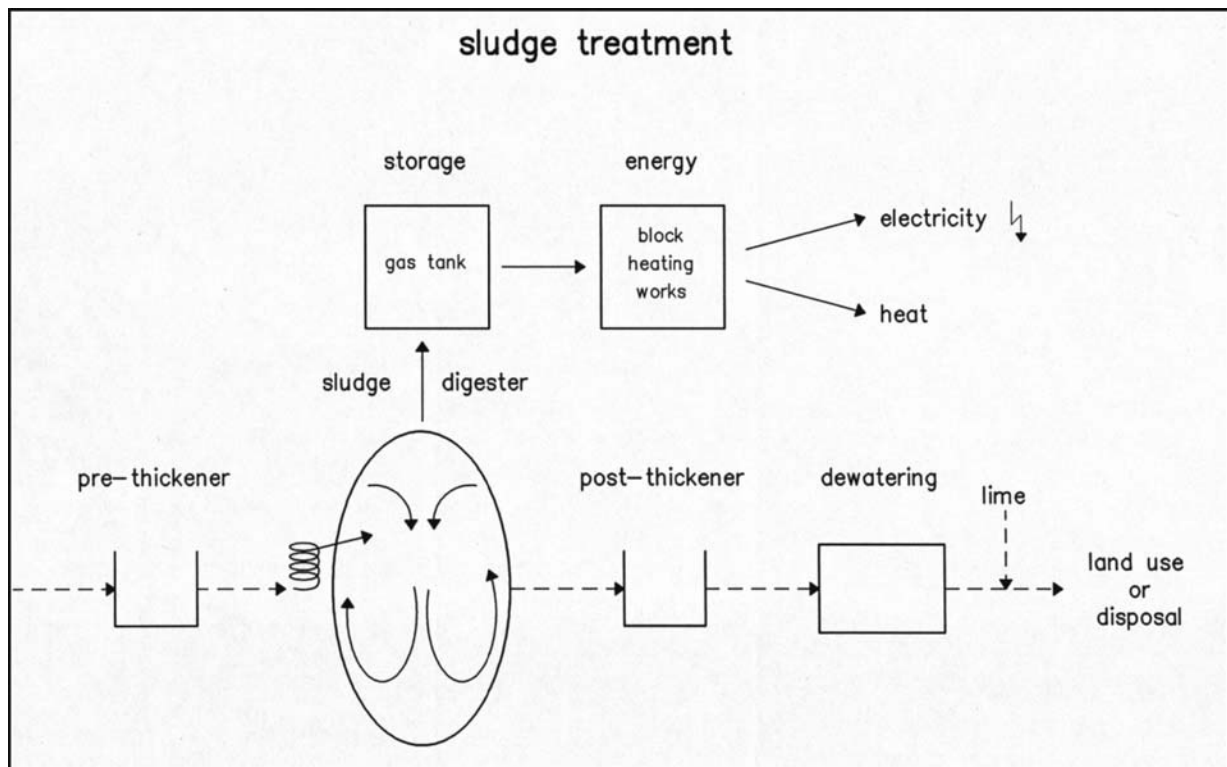


Figure 3: Present example for extended sludge treatment and use of biogas

### SMALL TREATMENT PLANTS IN RURAL AREAS

In rural areas with small communities, treatment ponds are often used. They are designed either as shallow ponds with natural aeration or as deeper ponds with a technical aeration. The high retention time in the ponds allows a treatment of combined water. If nitrogen removal is needed, ponds usually get upgraded with rotating disks, trickling filter or other fixed film material.

If the distance to a treatment plant is too large, septic tanks and multi-compartment septic tanks are in operation. For an extension of those tanks, new attachments use small technical equipment for integrating a trickling filter or an aeration tank. The septic tanks can also be combined with other treatment stages like using flow reed beds or sand filters.

For the decision among centralized or decentralized concepts, a detailed comparison and cost analysis of different solutions is often used. Operational and maintenance aspects have to be considered together with technical aspects.

### STORMWATER TREATMENT

Beside wastewater treatment, a reduction of discharged stormwater is strived for. Porous materials are preferred for ground works in new developed areas to percolate the clean stormwater as soon as possible. A storage of stormwater in hollows or ponds is possible to support percolation. A separate treatment in storage ponds can be necessary, if the stormwater runs on a polluted ground. Therefore mechanical sedimentation of the settleable suspended solids and a retention of the floating scum can be applied to keep the load into the receiving water small.

If sewage and stormwater get collected in the same sewer, the treatment of the combined water is limited. Smaller rainfalls with a hydraulic load of not more than 2 times the dry weather flow get treated like normal sewage in the treatment plant. If the hydraulic load rises, the surplus amount gets treated mechanical in a separate storage tank. New approaches try to use existing big sewer systems as an additional storage tank by using automatic weirs to control the runoff behaviour.

## VOCATIONAL TRAINING

Together with the rising treatment standards it became necessary to have further operators for more difficult and complex processes. First there were mainly construction workers, metalworkers or electricians who were interested in environmental trade. Since the 1990's there is a special 3-year-qualifying training in public utilities, supply grids and disposing of refuse and sewage. At larger wastewater treatment plants also engineers are on permanent staff.

Continuous further vocational training is more important than in earlier time. German universities and the German sewage treatment association 'ATV' provide diversified offers. For example the ATV provides a service for vocational training of the operational staff. Each 10 to 20 treatment plants are organized in groups of 'treatment plant neighbourhoods' and meet periodically at one of the plants.

## INDUSTRIAL WASTEWATER

The allowed contents and concentrations of wastewater discharged into the public sewer system are restricted. Treatment of high concentrated industrial wastewater is likewise more effective, than a previous dilution with municipal wastewater. Therefore pre-treatment and reuse of process water is gaining importance.

Food processing industry sometimes produces wastewater with a very high C/N-ratio. It might be useful to use those wastes as a carbon source for nitrogen elimination in municipal wastewater treatment plants. Concept studies should consider operational aspects together with a cost analysis and availability aspects.

## GUIDELINES

The framing guidelines by the European Union want to improve the water quality. Therefore, the water quality situation has to be reviewed and classified. Existing classifications in Germany for different oxygen-demanding sections of the rivers prove the efforts of recent years. But now new classifications of different biological parameters are needed in order to meet the characteristic situation of the river systems. This methodical approach is to rate the immission into the river and give an indication for most useful investments. Water quality models can support this aim. Within the next 9 years, this guideline is supposed to put into action.

## SUMMARY

About 90% of the inhabitants in Germany are connected to a public sewer system. The wastewater treatment and carbon reduction is advanced by a further nutrient removal. Even in rural areas the wastewater treatment gets extended, either by centralized, or by decentralized systems. Bigger treatment plants try to minimize their energy input and the amount of disposals. The treatment of stormwater and combined water is also improved. The described actions for a modern wastewater treatment in Germany are shown in Figure 4. To indicate the necessary investments, further demands should focus and correspond with the water quality situation.

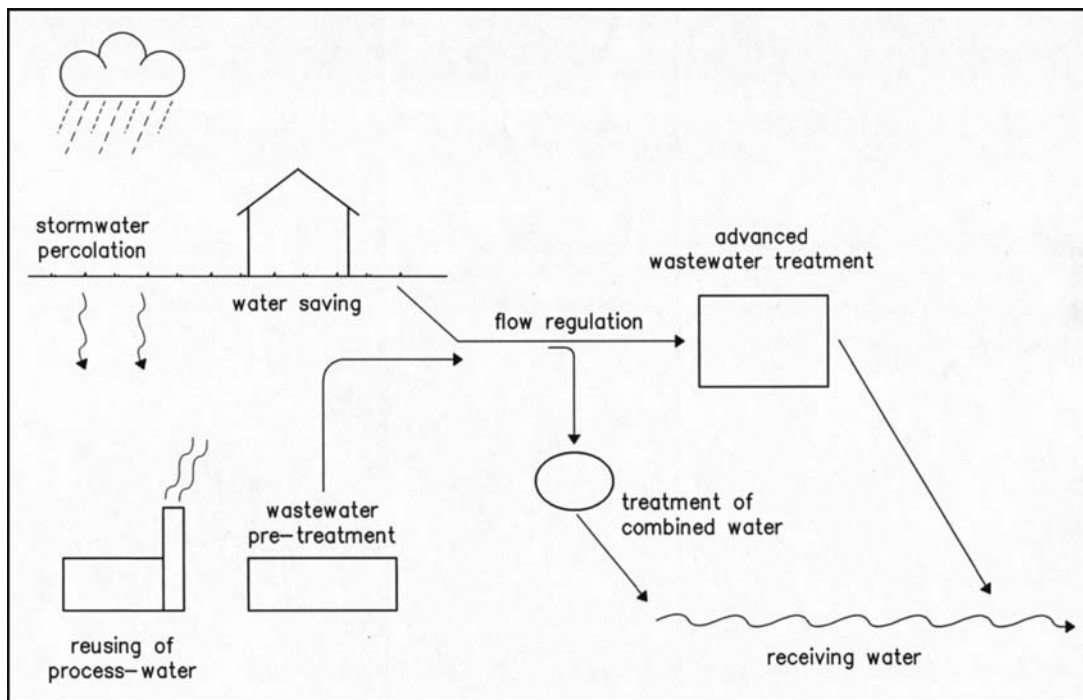


Figure 4: New approaches to improve the water quality situation

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