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EXAMPLES OF THE WASTEWATER DISPOSAL IN THE NEW FEDERAL STATES OF GERMANY

It is well known that the Federal Republic of Germany (FRG) and the German Democratic Republic (GDR) have reunited. New federal states with about 17 million inhabitants are as follows: East Berlin, Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt and Thüringen. This paper begins with the description of a sewage disposal at the time of the reunion and then discusses the improvements that will have to be made. Finally, a few examples of the situation in cities and rural areas will be presented.

1. THE SITUATION IN THE FORMER EASTERN GERMANY BEFORE 1990

The sewage disposal situation was analysed in the years 1990 and 1991. The main recipients of treated effluent are as follows: the Elbe flowing into the North Sea, the Oder/Neiße and several smaller rivers flowing into the Baltic Sea (see table 1). The international contracts on water pollution control of the North Sea and the Baltic Sea concern all the new federal states of Germany. For example, the considerable pollution loads of the Elbe are listed in table 2.

Table 1

Main drainage areas (according to [11], changed)

River	Area [%]	Inhabitants [%]
Flowing to the North Sea		
The Elbe	72.9	82.2
The Werra, the Aller, the Leine	5.5	4.9
Flowing to the Baltic Sea, especially the Oder/Neiße	21.6	12.9

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Table 2

Pollution load in the Elbe near Boizenburg, 1989 [4]

Mean water flow	613	m^3/s
COD	651,000	t/a
BOD_5	102,000	t/a
NH_4-N	36,700	t/a
PO_4-P_{total}	9300	t/a
Chloride	3,500,000	t/a
Lead	120	t/a
Cadmium	13	t/a
Chromium	280	t/a
Copper	380	t/a
Nickel	270	t/a
Mercury	23	t/a
Zinc	2800	t/a

Even big cities had only primary or extremely overloaded biological treatment plants. Since the 1990's closure of factories and construction of new sewage treatment plants have considerably reduced an enormous pollution of the surface waters.

The former failures of sewage disposal become clear when we are aware of the degree of connection to sewerages in urban areas (see table 3).

Table 3

Percent of inhabitants whose household had connection to sewerage in 1989 [4]

District	Drinking water net	Sewerage	Sewage treatment plant
Berlin-East	99.9	97.0	97.0
Cottbus	95.8	58.8	56.4
Chemnitz	94.7	78.3	49.9
Dresden	91.0	68.6	57.4
Erfurt	91.6	76.6	52.0
Frankfurt/Oder	91.9	56.1	56.1
Gera	98.5	85.2	49.6
Halle	95.0	69.7	53.0
Leipzig	95.1	81.2	64.6
Magdeburg	89.8	78.9	60.0
Neubrandenburg	95.6	62.0	55.5
Potsdam	80.5	50.6	50.5
Rostock	94.8	74.1	69.2
Schwerin	89.1	57.6	51.4
Suhl	99.9	89.8	33.9
Summary	93.3	73.2	58.2

Table 4 shows the percent share of various treatment methods applied at various sizes of population.

Table 4

Percent share of sewage purification methods used in 1989 for various sizes of population [4]

Purification method	Inhabitants/population equivalents [pe]	Percent share of the method applied [%]
None	2,500,000	15
Soil infiltration	1,600,000	10
Individual sewage treatment plant	3,000,000	18
Primary treatment (mechanical)	3,700,000	22
Secondary treatment (biological)	5,900,000	35
Sum	16,700,000	100

Every year about 4000 million m³ of industrial effluent, for the most part treated only inadequately or even untreated, were discharged into rivers and other waters.

Table 5 presents the estimated cost of investment needed for modernisation of the whole wastewater treatment system.

Table 5

Investment needed for modernisation of the whole wastewater disposal system [12]

Increase in the number of connections from 58 to 87%	10,4000 million DM	19.7 %
Sewerage restoration	20,0000 million DM	37.9 %
New primary treatment capacity	5,9000 million DM	11.2 %
New basic biological purification capacity	8,9000 million DM	16.9 %
New advanced purification capacity (N + P)	7,6000 million DM	14.4 %
Total	52,8000 million DM	100.0 %

Wastewater disposal will be efficient if the following requirements are fulfilled:

approximately 6200 km of sewerage,

repair of about 7400 km of sewerage (about 2/3 of the existing sewerage pipes are damaged),

development of a storm-water treatment concept,

increase in the number of connections to the sewage treatment system from 58 to 90%,

construction of 8 plants in which more than 20,000 population equivalents of sewage can be treated,

construction of 1000–2000 sewage treatment plants in about 6000 communities with more than 2000 population equivalents, repair and enlargement of the existing sewage plants, whose operation is inefficient because of old-fashioned machinery, hydraulical overload, overloaded biological purification, defective equipment, corrosion of concrete, missing mechanical sludge dewatering and insufficient sludge stabilisation [11].

The main industrial regions of the former German Democratic Republic had developed into regions of ecological crisis. The main industrial regions are as follows: Leipzig/Bitterfeld/Halle/Merseburg with its chemical industry and its quarrying and processing of brown coal, the Mansfelder Land with numerous copper works, the Niederlausitz region with mines and power plants, the uranium mining region in Sachsen and Thüringen and the coastal region of Mecklenburg-Vorpommern. The restoration and modernisation of nuisant sources of contamination, which were confined to small areas, have priority.

2. LEGAL PRECONDITIONS

2.1. WATER LEGISLATION

Because Germany is a federal republic, each state has its own legislation based upon federal laws. The new states of eastern Germany need three or four years until they establish their own water laws and ordinances.

2.2. MANAGEMENT STRUCTURES

Until the 1980's, in the older states of Germany, the management of sewage treatment plants was either under control of functional associations, acting on behalf of the

Table 6

Jurisdiction of sewage management in the Federal Republic of Germany (according [15], changed)

Civil law		Public law			
Private companies: limited company, joint-stock company, limited partnership	Participation in a private company	Works with a municipal budget	Works with an own budget	Functional association	Public law contracts
Legally and economically independent		Legally and economically dependent		Fusion of municipalities with new legal status	Transfer of responsibility to other municipalities

local municipalities, or several municipalities together managed the sewage disposal (river associations). Such a situation took place because the local authorities felt obligated to respect public law established for management of sewage. Since the middle of the 1980's some treatment plants were placed under management of independent public bodies (in German called "Eigenbetriebe") that had their own budget. Some of the treatment plants were completely or partly privatised. After the necessary legislation had been passed in new states, these different forms of management were adopted in such a way as to reduce the costs of the many modernisation projects. An overview of the jurisdiction of sewage management is listed in table 6.

3. CHANGING CONDITIONS

3.1. GENERAL IMPROVEMENTS

During the period of 1990 to 1994, 40,000 million DM provided by different national and international aid programmes were spent on environmental protection. This includes remediation of contaminated sites and air control. The quality of water in lakes and rivers has improved considerably due to the initiation of these measures. From 1989 to 1993 there was stated an important reduction in contaminant content in the Elbe [5]:

cadmium, from 0.45 to 0.32 $\mu g/dm^3$,

mercury, from 0.78 to 0.11 $\mu g/dm^3$,

adsorbable organically bound halogens (AOX), from 100 to 60 $\mu g/dm^3$.

In the rivers, ammonium and phosphorous content decreased considerably, which was accompanied by a rise in oxygen concentration. The sale of phosphate-free detergents caused a 42.86% reduction of the phosphate load discharged by municipal sewage plants. This represents 8000 metric tons of phosphate as opposed to 14,000 metric tons per year.

The measures are not complete yet. In 1995, the German federal government decided to allocate 6600 million DM per year for a period of ten years. In addition, the European Union contributes about 27,000 million DM per year to support water protection and will give this help until 1999 [5]. At the beginning of 1994, thirty one new sewage plants, costing a total of 3000 to 4000 million DM, were completed or erected.

The discussion about wastewater management is often subjective and many people tend only to see high costs that it involves. Few of them are able to realise how much has been accomplished by the investments. Here we present a few examples of the successes of the German federal states of Brandenburg, Mecklenburg-Vorpommern and Sachsen-Anhalt.

3.2. BRANDENBURG

The percentage of households connected to the sewerage system raised regionally in the years 1990–1995 from 53.5 to 60%. There is still an essential difference between rural and urban areas. While 40–60% of country households are connected to sewers, more than 96% are connected to sewers in cities. The water quality has improved in most lakes and rivers. In 1990, not one sizeable sewage plant complied with technical standards set by federal legislation (water resources policy act). By 1996 three quarters of 102 sewage plants, each built for the population equivalents of over 5000, were able to reduce nutrients and to abide by the regulations [1].

3.3. MECKLENBURG-VORPOMMERN

From 1990 to 1996 two hundred and twenty sewage plants were newly built or enlarged (compare table 7).

Table 7

The number of newly built or englared sewage plants from 1990 to 1996 in Mecklenburg-Vorpommern [13]

Pollution equivalents	< 1000	1000–5000	5000–20000	20000–100000	> 100000
Number	Approx. 130	44	26	17	3

Since 1993 the quality of inshore and coastal waters has been under observation. A network of monitoring stations and a number of different projects allowing us to establish the quality of flowing waters, lakes, coastal waters and ground water have been created. They mainly involve:

optimisation of the monitoring network to record data referring to rivers and coastal waters,

close surveillance of lakes and examination of the conditions of 600 lakes larger than 10 ha,

construction of a new network to monitor ground water quality,

including heavy metals, organic industrial chemicals, pesticides, chelating agents and polycyclic aromatic hydrocarbons (PAHs) to the parameter spectrum of investigation programmes,

investigation of sediments in rivers, lakes and coastal waters,

preparation of a biological monitoring programme involving determination of the contaminant intake of the Biota Bivalve and a survey of the macro-zoobenthos and macrophyten.

The present state of rivers can be described as follows:

1. Owing to higher oxygen concentration and lower organic matter content, about 70% of rivers reached in 1995 a water quality grade of 2. This was due to the improved sewage treatment and a decline in the surface run-off of agricultural nutrients.

2. Implementation of the third-stage precipitation units in sewage plants has reduced the phosphate discharge, thus decreasing the phosphate content in rivers. Utilisation of phosphate-free detergents and lower direct intake of agriculturally-related phosphates allow better control of pollution (table 8).

Consequently, the contamination level of the Baltic Sea along the Mecklenburg-Vorpommern coast has lowered considerably. Before 1990 the discharge of orthophosphates from inshore waters into the Baltic Sea amounted to 330 metric tons/year. By 1994 it decreased to 200 t/a. The increase in 1993 and 1994 resulted from high precipitation rates accompanied by high mean run off. The phosphate load in the outlets of the sewage plants has decreased to a level of 20%.

Table 8

Ortho-phosphate discharge from the Mecklenburg-Vorpommern inshore waters into the Baltic Sea [13]

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Discharge [t/a]	290	310	370	330	310	320	350	230	160	190	220

3. In the inshore waters, there is observed that ammonium content is on the decline, while nitrate content increases. These two compounds mainly due to diffusion penetrate into the rivers. There is a close relationship between precipitation, the resulting surface run off and nitrate loads.

4. Heavy metals, industrial organic compounds and pesticides are either undetectable or present in very low concentrations only. Only occasionally the concentrations are higher than permissible levels.

5. When the sewage treatment plant in Stralsund was put into operation there was not longer any ban on bathing.

Sixty-four sewage plants in Mecklenburg-Vorpommern, each treating sewage produced by a population of over 10,000 pe, have to apply European regulations governing the treatment of municipal effluent. By 1998, due to modernisation, these plants will largely abide by the regulations. Additionally more than 80% of households are connected to the municipal sewerage. Thus, the sewerage can be expected to conform to legislation within the next 10 years.

3.4. SACHSEN-ANHALT

During the period of 1990–1996 one hundred and seventy five biological sewage plants, 64 equipped with the units allowing phosphorus and nitrogen removal, were erected in Sachsen-Anhalt. All of 391 municipal effluent treatment plants were in operation by the end of 1996 [3]. Improvements made between 1990 and 1996 are shown in table 9.

Table 9

Development of municipal sewage treatment in Sachsen-Anhalt in relation to its population [14]

Year	1990	1996
Inhabitants	Approx. 2.9 million	Approx. 2.8 million
Decentral treatment (septic tanks)	14.8 %	7.5 %
Connection to a sewerage	66.1 %	76.2 %
Connection to sewage plants	56.1 %	73.9 %
Number of sewage plants	287	391
Primary clarification	51.1 %	31.6 %
Biological purification	33.6 %	22.5 %
Further purification	0.5 %	38.3 %

The success of the measures is reflected by the decline in contaminant loads in inshore waters (compare table 10).

Table 10

Pollutants load of the Elbe (without the Mulde and the Saale) in Sachsen-Anhalt [3]

Municipal discharge					
Year	COD	BOD_5	$N_{inorg, total}$	P_{total}	AOX*
	t/a	t/a	t/a	t/a	t/a
1992	11127	6192	1305	176	2.62
1993	8863	4735	1053	139	2.51
1994	7368	3845	1147	135	2.80
1995	4746	2431	982	77	2.30
Industrial discharge					
Year	COD	Hg	$N_{inorg,total}$	P_{total}	AOX*
	t/a	t/a	t/a	t/a	t/a
1992	5.639	0.0005	1.699	60	2.09
1993	3.379	0.0002	302	63	0.83
1994	1.258	0.0007	290	15	0.50
1995	463	0.0003	101	10	0.05

* Adsorbable organically bound halogens.

About 3000 million DM were invested. However, we are in need of finding additional 6000 million DM, 1600 million DM are to be invested in the construction and modernisation of sewage plants and 4400 million DM in municipal sewerage networks and connecting mains.

4. PROJECT EXAMPLES

In order to demonstrate how the solutions can be found for each special case, the following exemplary projects have been selected:

Sewage plant Dessau. It displays quickly changing conditions (pe: 350,000/185,000).

Sewage plant Gotha representing urban conditions (pe: 150,000).

Sewage plant Bitterfeld-Wolfen, which is strongly influenced by its industrial surroundings (pe: 422,000).

The small town Belzig representing rural conditions (pe: 11,000).

4.1. PROJECT DESSAU

Planning of the new sewage plant Dessau proved that the assessment of economic development after the reunion of east and west was completely false because of its overestimation. Dessau is a town on the Elbe with a population of about 100,000. It is characterised by the machine tool, chemical, sugar, and yeast industries.

In March 1991, an engineering office obtained the plan of a sewage plant for Dessau. It was based on a future population of 350,000 and its cost was estimated to be 250 million DM. In preliminary planning, submitted in November 1991, there were assumed a population of 300,000 and investment of 200 million DM. In the following months, it became clear that economic growth would not be as great as we had expected. The plan prepared in August 1992 recommended a primary clarification for 230,000 pe and an investment of 180 million DM. According to the estimates of economic development provided further, a primary development assessed for a population of 185,000 led to a cost of 100 million DM. In July 1994, in advertisement an investment was established to be 90 million. Finally at the end of 1994 the commission decided to give the funds of 78 million for the programme.

The sewage plant was put into operation in June 1997. In this plant equipped with belt screens, grit separator, grease separator and a preliminary settling tank a primary clarification takes place. The biological treatment entails nitrification, denitrification and phosphorus removal in an activated sludge tank and secondary settling tank. A micro-strainer is applied in a final stage. The sewage sludge is anaerobically treated and dried. The gas produced is used as a fuel in power station. The sewage sludge can be utilised as compost, incinerated or deposited, depending on the demand. The water quality applies to European regulation [2].

4.2. PROJECT GOTHA

Before German reunion Gotha had primary clarification tanks, which were installed in 1960, and a trickling filter working efficiently since 1910. The incoming pollution load of 190,000 population equivalents had to be treated in a mechanically operating plant designed for a capacity of 130,000 pe only. The sewage produced by 56,000 inhabitants and the effluent from food industries processing vegetables, meat, fat, emulgators and milk had to be treated. Since 1939 sewage sludge has been treated in a heating digester. After 1960 an open earth basin enabling stabilising the sludge complemented this method. All the buildings were derelict. Because, in March 1990, the plant shut down, plans for new installations were commissioned in May 1990. This happened just before the currency union. In January 1991, a general contractor was ordered to construct a new plant with the prerequisite to deliver the blue prints within 6 months and to complete the project within two years. The plant, that was constructed to achieve the contemporary threshold values (table 11), had the capacity to treat 150,000 population equivalents, including sewage from 22 neighbouring villages.

Table 11

Threshold values of the sewage plant Gotha [10]

BOD_5	COD	N–NH_4	P_{total}	$N_{inorg.}$
mg/dm^3	mg/dm^3	mg/dm^3	mg/dm^3	mg/dm^3
15	75	10	1	18

In November 1991, after nine months, primary clarification unit was ready for operation. Twenty four months later the plant was tested.

The plant is equipped with the following installations (figure 1) [16]: coarse screen (80 mm), fine screen (10 mm), storm-water stand-by tank, aerated grit removal tank, preliminary clarification tank (50 minutes under storm conditions and 25 minutes under good circumstances), bio-P-tank (1.8 hour contact with dry weather), meander tanks for simultaneous nitrification/denitrification (sludge is 16 day old, almost continuously variable from aerobic to anoxic to anaerobic zones). Treatment technology involves the following unit processes: intermediate settling, chemical precipitation, secondary clarification using laminar separators, desulfuration and sludge utilization. The plant is also equipped with heating power station and a microelectronic operation control system.

Total nitrogen concentrations at the outlet are plotted in figure 2. They are expressed by a curve representing one year of operation. Effective nitrogen removal approaches 88%. In spite of extreme feed fluctuations, on account of discontinuous flows of faeces, which is a typical situation in the new federal states, mean concentration in a two-hour composite sample falls below 4 mg/dm^3 with maximum values of 13 mg/dm^3. A maximum value of 11.9 mg/dm^3 (maximum N–NH_3 = 3.6 mg/dm^3) was determined in 1996 [8].

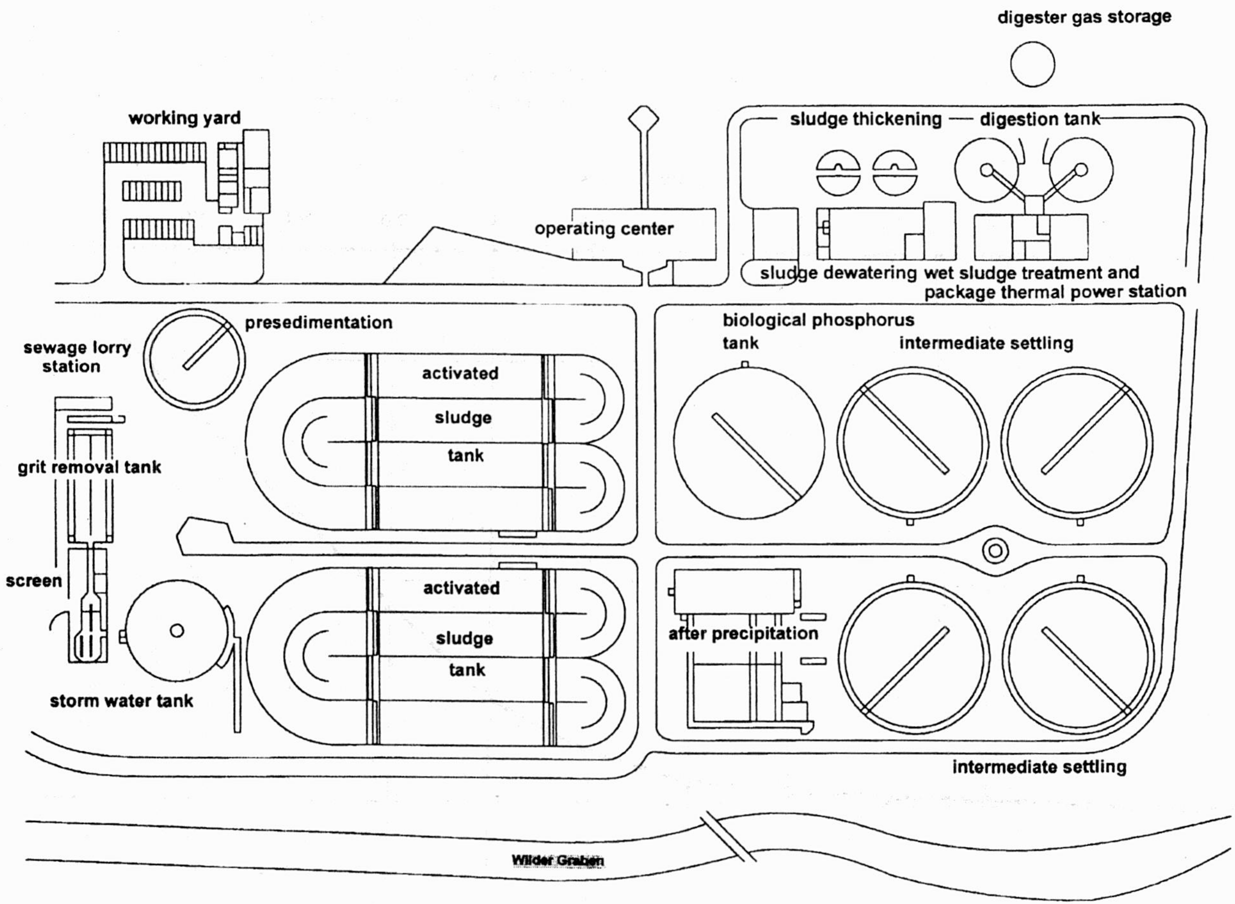

Fig. 1. Diagram of the sewage plant Gotha [9]

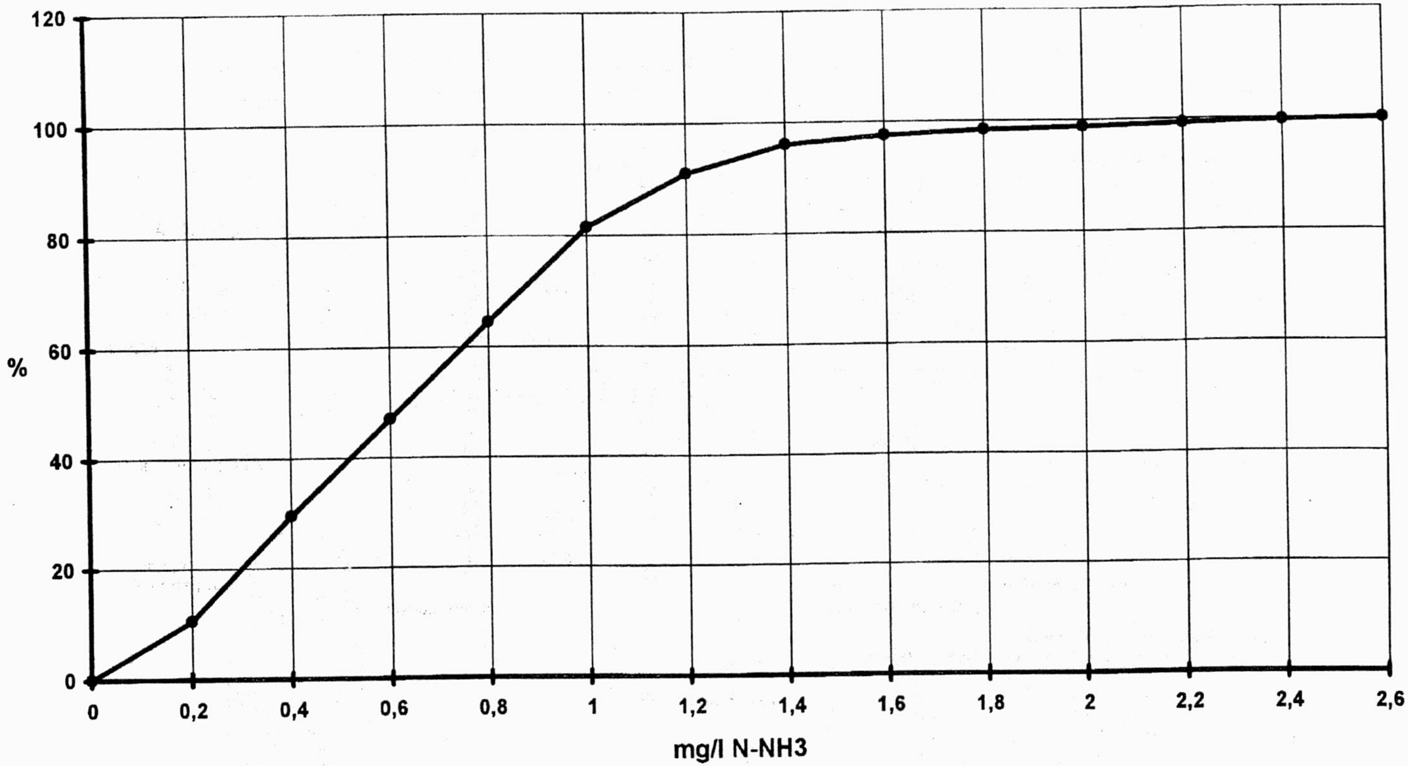

Fig. 2. Cumulative frequency of ammonium nitrogen discharged by the sewage plant Gotha in 1994 [9]

The supply conditions are not appropriate for biological phosphate removal due to the total phosphorus input concentrations oscillating between 5 and 20 mg/dm^3. Furthermore, the P_{total}/BOD_5 ratio of 0.08 is unsuitable. However, biological degradation on its own without precipitation produces a total phosphorus discharge falling below 0.5 mg/dm^3 (98.5% efficiency), thus making a secondary precipitation unnecessary.

The total net investment of 77.6 million DM (517 DM/pe) divides into 41.9 million DM for construction work, 29.8 million DM for plant machinery, 4.6 million DM for fees and 4.6 million DM for others (development and real estate). The state of Thüringen and the federal environment ministry provided 19.7 million DM [9], [16].

4.3. THE JOINT VENTURE SEWAGE PLANT BITTERFELD-WOLFEN

This project represents co-operation of the municipality and industry in a region that is strongly influenced by production of chemicals and photographic products. The construction of the joint sewage plant fulfilled one of the requirements for upholding and developing industrial growth in the area of Bitterfeld-Wolfen. A former state which owned chemistry corporation was split up in 1990 and transformed into a 600 ha large chemistry park. The sequence of development was as follows:

April 1990:	construction and operation of a pilot plant,
March 1991:	finding subcontractors by the general contractor,
September 1991:	commissioning the application for permits,
October 1991:	foundation of a limited company (52% belonging to 2 co-operative sewage associations and 48% to the chemical industry),
November 1991:	submitting the application papers,
December 1991:	submitting an environmental compatibility test,
January 1992:	commissioning the detail planning,
June 1992:	permission granted by the water authorities for construction and operation,
July 1992:	construction begins,
December 1993:	operation of parts of the plant,
August 1994:	completion of construction and acceptance of the plant.

The plant is designed for a population equivalent of 422,000 with a feed of 77,000 m^3/d or 4800 m^3/h. Between the planning stage and completion of the plant a considerable decline in growth of the chemical industry took place; commercial areas failed to develop as had been expected. In addition, connecting the houses of several communities to the sewerage was delayed. Nevertheless, owing to the damaged sewerage, that has not yet been repaired, extra material enters the system, causing the plant to operate periodically at 100% of its capacity.

The investment for the sewage treatment installation (without sludge processing) amounts to 226 million DM. A further approximate 83 million DM were spent on pump stations, pressure and delivery conduits.

The industrial effluent reaches the plant via 10 pressure pipelines or by tanker vehicle and is mixed in tank to be uniformed. Lime slurry, iron chloride ($FeCl_3$) and polyelectrolyte solutions are used in order to coagulate and precipitate the effluent and thus to remove mainly phosphate and heavy metals. If problems occur the effluent can be transferred to an emergency tank. Dye effluent is separately prepared and added to the wastewater, which is then treated with an iron sulphate solution and lime slurry until the colouring disappears.

The municipal effluent is conventionally preclarified using the following devices: submersible motor pump station, screen with 10 mm band distance, aerated grit removal tank and grease separator, fine screen with 2 mm band distance, and mixing tank.

Municipal effluent as well as industrial effluent are treated in slightly contaminated BIOHOCH-reactors, in which the following processes take place:

enhanced removal of industrial effluents containing resistant substrate, if necessary by adding activated charcoal,

nitrification/denitrification of industrial effluent using a certain amount of decomposable municipal sewage,

enhanced removal of the sewage contaminants by nitrification/denitrification,

phosphorus removal via precipitation with iron (III) chloride.

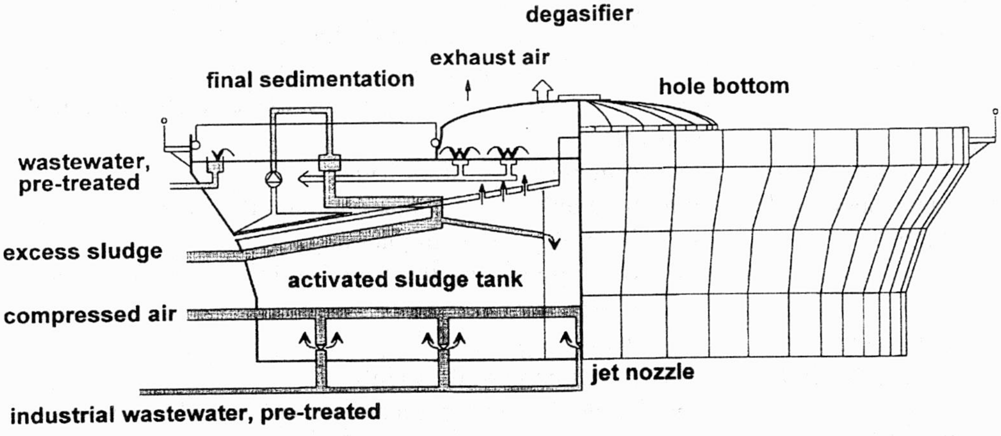

Fig. 3. Diagram of a BIOHOCH-reactor at the sewage plant Bitterfeld-Wolfen [7]

A BIOHOCH-reactor (figure 3) consists of a cylindrical centre piece that is attached to denitrification unit. A horizontal, perforated metal sheet divides the centre piece into two sections, the lower for aeration and the upper for bubble degassing, forming an activation compartment. Radial air jets allow aeration. A ring shaped secondary clarifier is mounted at the top part of the centre piece.

The separated sludge is dehydrated in a screw densifier in such an extent that it finally contains about 5–6% of water. Then it is transported to a sludge tank, where a grease from the municipal sewage and industrial effluent's precipitate is added. After further dehydration in a centrifuge the sludge is finally treated with lime and deposited. The use of a landfill is a temporary measure until an incineration plant is built.

The efficiency of the removal process is reflected by the following figures: 90% removal of COD and phosphorus and higher than 50% removal of nitrogen.

4.4. PROJECT BELZIG

While modernisation of the sewage system in most cities and large towns is either complete or near completion, it has only begun in some of the small towns. In villages, the sewage treatment has in part remained as it was in 1990. A good example is the community of Belzig in Brandenburg.

Belzig is a small town inhabited by approximately 8000 people. Within a radius of about 15 km there are sixteen villages each with inhabitants' number ranging from 100 to 700 and its own administration. The local structures are shown in figure 4. The region is, with the exception of Belzig that has a small commercial trading area, an agricultural area. There is an old sewage plant in Belzig, but it is in need of repair. The sewage sludge is collected from the surrounding villages by a road. In Belzig itself, a sewerage also needs modernisation.

The undertakings to control this situation were carried out slowly because it was not quite clear who was responsible for modernisation of a sewage plant. Owing to the future financial burden, there was a general reluctance to take any steps towards modernisation and a little environmental interest to protect the ground and surface waters. There was nobody in the administration who wanted to put the stress on development. A change occurred in 1995 when the communities were obliged by the Brandenburg State legislation to develop concepts of how to treat and dispose sewage.

When an engineering office started to develop the concept of sewage disposal, it proved difficult to arrive at consensus in 16 villages. The acquisition of the necessary basic information to work with was a further problem. Plans and knowledge of the existing constructions and their condition could only be partly acquired, on account of unknown or undefined responsibilities of civil servants. A concept was completed within half a year only.

Because there were no proper existing sewerage and treatment plant, there was opportunity to examine a whole range of solutions and alternatives. There were 5 alternative methods of sanitary wastewater drainage to choose from: 1) a conventional combined sewer system, 2) a conventional separate sewer system, 3) a modified natural fall sanitary sewer system, 4) a pressure pipe system and 5) a subpressure pipe system. The rain water drainage takes place on the surface via ditches and depressions, if it is not a part of the combined systems mentioned above.

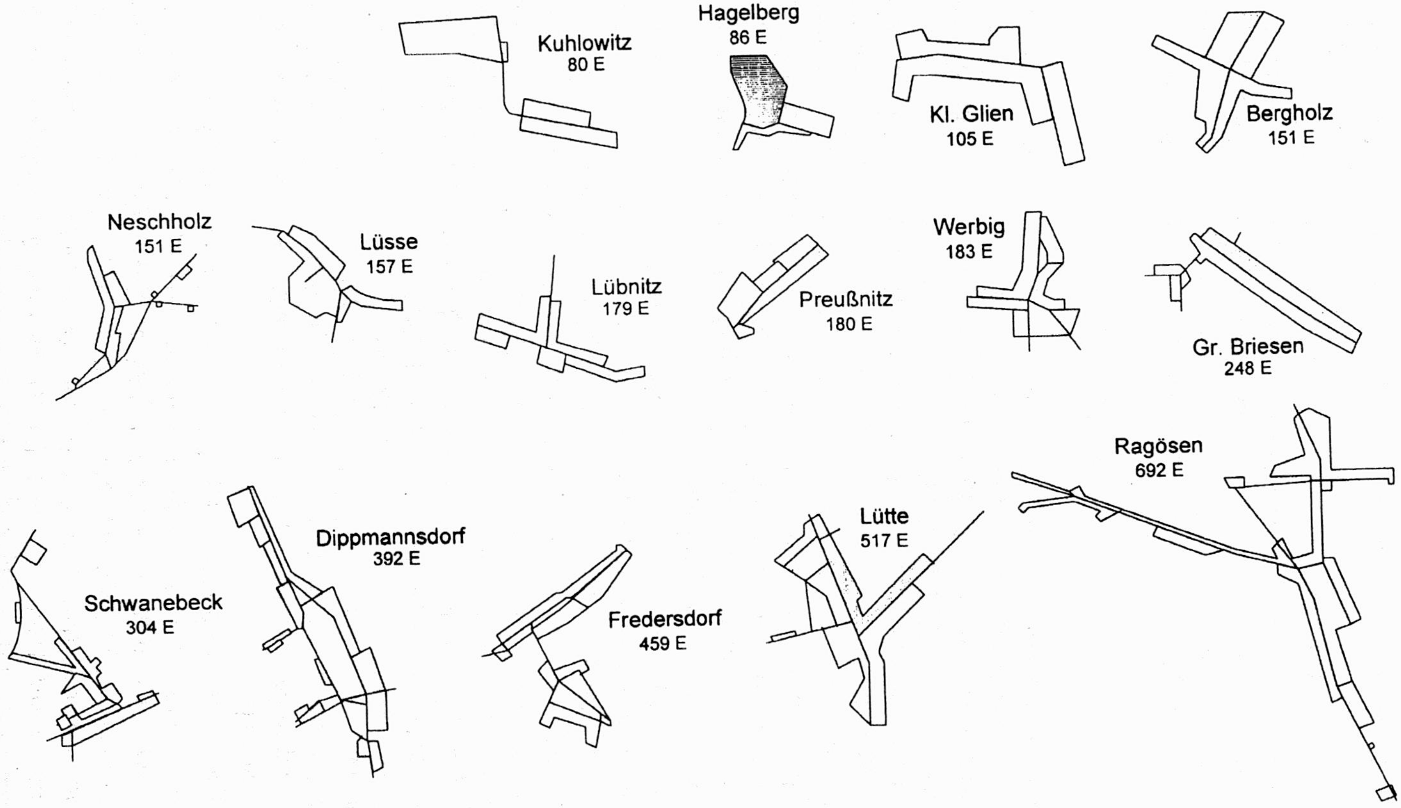

Fig. 4. Local structures of the villages belonging to the community of Belzig

Modernisation and use of the existing household septic tanks offer several alternatives when connecting them to 2, 3, 7, 10 or 14 different sewage treatment plants.

All alternatives were drafted technically and economically. In this review of alternatives, depreciation, interest rates and operational costs were taken into account and evaluated. Obviously the drainage of rainwater in an open system in a rural area like this is much cheaper than in an enclosed rainwater drainage system.

The concept of maintaining the catch pits proves to be most uneconomical although it is obviously the one involving the smallest amount of money. A considerably modified gravity line sanitary system with pipes running mainly along municipal property has been decided upon. In exceptional cases at certain low levels the catch pits will be maintained. The main characteristics of the modification are as follows:

Choice of route: Conventionally sewerage runs alongside roads and only on property owned by the council. Costs can be reduced by laying the pipes below such surfaces as road verges, ditch embankments or on private property. Thus it is possible to save up money which otherwise will be spent on reinforced ditch fillings. The difficult access to private property and the negotiations with owners are the disadvantages. Each owner has to agree, compensation must be paid, and entries made in the land register.

Minimum nominal diameter: Because of the danger of stoppages the smallest standard diameter is set as DN 250. Under circumstances DN 200 can also be used. The choice of a nominal diameter of DN 150 is also feasible, provided that the minimum bed gradient of 1:DN, equivalent to 0.67%, is maintained. Compensating for 50% of external water, such a system would be adequate for 1200 inhabitants. While the danger of a stoppage increases with a smaller nominal diameter, it decreases with higher flow velocity, which occurs with well-filled pipe cross sections. Recently constructed systems of this dimension work without any significant problems.

Reach: According to German technical norms the reach of the pipes with small nominal diameters should be between 50 and 70 m. These lengths are derived from old-fashioned methods of pipe cleaning with a winch. Modern flush vehicles have hose pipe of the length up to 200 m (it is used for rinsing out the pipes which are clogged up) and video cables of equal length. Vehicles operating on waste deposit landfill sites clean drainpipes 800 m long. When the number of manholes is reduced, the smaller volume of external water can penetrate the system through the cover holes. Lengthening of a pipe up to 150 m is perfectly reasonable, provided that two inexpensive vent pipes are installed to allow the necessary ventilation.

Depth of excavation: The connection of basement drainage to sanitary sewerage by natural fall is not absolutely necessary, so that the street sewerage pipes can be laid in shallower beds. The basement drainage can be accomplished using drainage pumps whereby reflux valves according to the German industrial norm (DIN) of 1986 are to be installed.

Vent pipes: Replacing manholes with vent pipes can reduce investments. The use of vent pipes with minimum nominal diameters from DN 400 to DN 450 allows an easy entry of cleaning and inspection apparatus. Vent pipes should not be placed below road surfaces but below neighbouring surfaces that do not have to withstand substantial pressure, e.g. verges, bike and footpaths.

Use of plastic pipes: Rigid drainage pipes are made of concrete, fibre cement, stoneware or ductile cast iron. Feasible alternatives are pipes made of PVC and PE. Their qualities are as follows: chemical resistance, very high abrasional strength, light weight, easily workable, smooth internal surface, pipe lengths up to 20 m resulting in smaller number of connections and lower cost. The disadvantages are low strength, e.g. low hardness, and low tensile strength resulting in deformation of cross sections, which reduces the hydraulic efficiency and causes problems with the connections made later. PVC has a lower than PE chemical resistance to certain solvents, PE pipes need to be protected against UV light.

Gradient pressure conduit: Delivery pipelines with few or no side connections and enough surface gradient are cheaper than gradient pressure conduits. They can operate with pump stations if needed. They do not require a constant bed slope, and high and low levels of hydraulic pressure gradient are acceptable. Also the manholes and flushing shafts can be placed further apart.

Most of these modifications are not described by German norms. At present the risks and liability of engineers, whose conceptions deviate from the standards, are intensively discussed. The latest state ordinances permit these modifications.

The results of the economic comparison are displayed in table 12. The concept of a modified gravity line system exclusively for sanitary effluent is recommendable.

Table 12

Results of an economic comparison of alternative sanitary drainage systems for the community of Belzig [6]

Type of construction	Investment	Project-costs-cash-value
Conventional natural fall	100%	55%
Modified natural fall	50%	54%
Pressure sewerage	62%	89%
Subpressure sewerage	65%	100%

A comparison of various drainage systems shows, when the cost of the pumping stations, delivery pipelines and sewage plants is taken into account, the most favourable concept of 7 treatment plants. Because the recipient waters are too far or their volume is too low, the treated wastewater will have to be reinfiltrated, and sewage will need an extensive purification. The "container sewage treatment plants" discussed at the moment are of low cost, but they are characterized by inadequate process stability and frequently insufficient nutrient removal. In this case, they would come only as a transitional solution in question. At present in the Federal Republic of Germany, various institutes test biological pond and plant water treatment system with improved nitrogen and phosphorus removal. Such a system is also planned for the community of Belzig.

Although the most economic solution has been chosen, some political problems are expected, because, in spite of the fact that the project being subsidised by the state or Europe, part of the cost will have to be paid by citizens, who are often underpaid or unemployed.

5. PROSPECTS

It is a well-known fact that the financial help has considerably improved the quality of surface waters. But in order to meet the requirements of the European regulations, a substantial effort will have to be made, particularly in medium-sized and small towns. Especially diffusible contaminants remain a problem. The discussion about the most economic methods will be continued. From a technical point of view, more economic methods, which usually deviate from conventional techniques, will gain popularity at the expense of a lower standard.

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PROBLEMY GOSPODARKI WODNO-ŚCIEKOWEJ WE WSCHODNICH LANDACH PO ZJEDNOCZENIU NIEMIEC

Opisano sytuację w gospodarce wodno-ściekowej we wschodnich regionach zjednoczonych Niemiec i przedstawiono propozycje polepszenia tej sytuacji. Zaprezentowano kilka przykładowych rozwiązań dla wybranych miast i gmin. Opisano sytuację na terenie dawnej NRD w latach 1990–1991 i zaprezentowano rodzaj przedsięwzięć, zmierzających do poprawienia stanu ekologicznego tych obszarów. Przedstawiono również aspekty prawne, obejmujące stronę praktycznego stosowania lokalnych przepisów prawa wodnego, oraz zmiany w strukturze zarządzania gospodarką wodno-ściekową. Podano konkretne przykłady polepszenia sytuacji ekologicznej w trzech regionach dzięki budowie i modernizacji sieci kanalizacyjnych i oczyszczalni ścieków oraz przykłady zastosowania wariantowych rozwiązań projektowych.