

# Sewage Sludge Treatment in Large Cities Using the Example of Berlin

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## 1. Introduction

The waste water of Berlin is purified in six sewage treatment plants and accordingly, there are also six waste generation sites for sewage sludge. This division has developed historically; there were already sewage treatment plants at some of the current locations in 1929/1930.

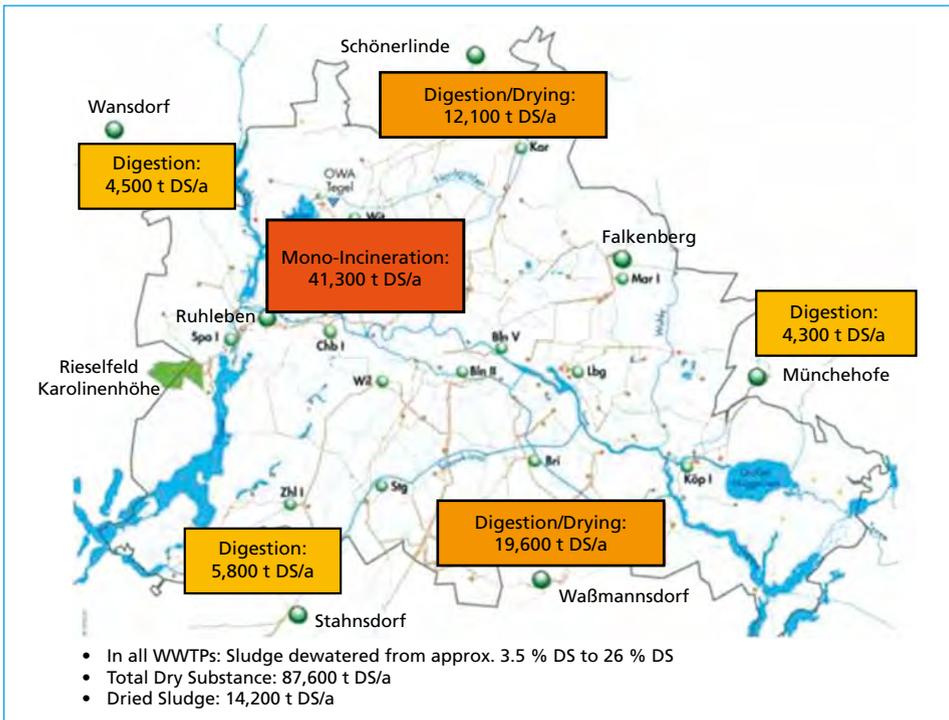


Figure 1: Sewage sludge volume Berlin

Apart from the Ruhleben sewage treatment plant, with sludge incineration, the sites of the other five sewage treatment plants are in surrounding areas of Berlin. In these five sewage treatment plants, the sewage sludge is digested in digesters (mesophilic digesting at approx. 35 °C) and subsequently drained in centrifuges. Two of the sewage treatment plants can dry the drained sludge to approx. 94 % dry matter content (complete drying, using drum dryers).

## 2. Locations and treatment methods

The locations of the sewage treatment plants and some key figures and treatment methods:

Data from 2010

Table 1: Key figures for the sewage treatment plants

	Purification capacity m <sup>3</sup> /d	Sludge volume t dry mass/a	Sludge type
Waßmannsdorf	230,000	19,600	Digested sludge
Stahnsdorf	52,000	5,800	Digested sludge
Schönerlinde	105,000	12,100	Digested sludge
Münchehofe	40,000	4,300	Digested sludge
Wansdorf	40,000	4,500	Digested sludge
Ruhleben	240,000	41,300	Raw sludge

Table 2: Sludge treatment methods

	Biological phosphorous removal yes/no	Separate excess sludge thickening yes/no	Sludge treatment -
Waßmannsdorf	yes	yes	Drainage/Drying
Stahnsdorf	yes	yes	Drainage
Schönerlinde	yes	no	Drainage/Drying
Münchehofe	no	no	Drainage
Wansdorf	yes	yes	Drainage
Ruhleben	yes	no	Drainage/Incineration

The drainage occurs using centrifuges in all six sewage treatment plants, in order to achieve continuous operation and essentially keep the sludge in a closed system, due to odours.

For the digesting, digesters are generally used with a volume of 8,000 m<sup>3</sup> per tank. Exceptions from this are only Wansdorf sewage treatment plant (tanks with a capacity of 3,500 m<sup>3</sup> each) and Stahnsdorf, where digesting chambers (built circa 1930) are in operation.

The complete drying in the Waßmannsdorf and Schönerlinde sewage treatment plants occurs with the same models of drum dryers, there are each of three lines in Schönerlinde and currently also in Waßmannsdorf (the fourth line in Waßmannsdorf was decommissioned due to a high level of wear and tear). A dry mass content of approx. 94 % is achieved with the drying plants, with output dry mass contents of approx. 26 to 27 % after the drainage centrifuges.



Figure 2: Sludge incineration plant in the Ruhleben sewage treatment plant

In the sludge incineration plant in the Ruhleben sewage treatment plant, the sewage sludge is incinerated in fluidised-bed furnaces. Three fluidised-bed furnaces are installed, where by one furnace serves as a reserve.

For the incineration of the sewage sludge, heating oil is used for backup firing, as the sludge cannot be previously drained sufficiently using mechanical methods, so that no backup firing is required.

The flue gas from the incineration plant is initially ducted through an electric filter for ash separation and then purified in a wet, alkali flue gas cleaning plant. This creates gypsum, which is disposed of as waste.

In order to ensure compliance with the limit values for mercury, active charcoal is dosed at the end of the waste heat boiler. The loaded active charcoal is separated together with the ash in the electric filter and the ash is transferred to a redundant landfill site for recycling.

### 3. Disposal methods

The following disposal methods are not available for the sewage sludge from the Berliner Wasserbetriebe sewage treatment plants:

- Due to exceeding of limit values for heavy metals under the Sewage Sludge Ordinance in the sludge from all sewage treatment plants, it is not possible to **transfer it to agricultural areas**. The agricultural areas are also not available in the nearby and further vicinity of Berlin, due to the large volumes to be disposed of.
- The addition of sewage sludge, together with other organic materials into plants for **composting** was carried out for partial quantities until mid-2002, however, this was discontinued due to the aforementioned limit value excesses.
- **Landfilling** of the sewage sludge without further pre-treatment has been prohibited for legal reasons (Technical Directive on Municipal Waste/German Waste Storage Ordinance 2001/Landfill Directive 2009) since 2005.

The following disposal methods for sewage sludge are currently used by Berliner Wasserbetriebe:

- Co-incineration of a part of the digested sewage sludge from other Berliner Wasserbetriebe sewage treatment plants in the **sludge incineration plant** on the premises of the **Ruhleben** sewage treatment plant.
- The sewage sludge dried in the Waßmannsdorf and Schönderlinde sewage treatment plants is used as a secondary fuel in **power plants** (thermal recycling) or in a **cement works** nearby Berlin (material and thermal recycling). For economic reasons (high servicing and maintenance costs) only part of the sewage sludge generated in both sewage treatment plants is dried.

- All sewage sludge that is not co-incinerated in the sludge incineration plant in Ruhleben and not dried is provided for **co-incineration in power plants** with a dried weight content of approx. 25 %.

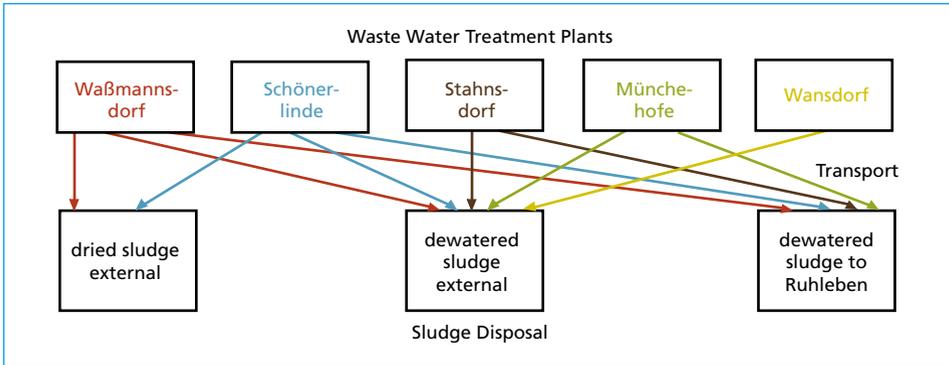


Figure 3: Disposal methods for sewage sludge

As the prices for the disposal of dried and drained sludge are tiered according to quantities, this gives rise to an optimisation task with regard to minimisation of the costs for disposal and the plant operation. This task is solved by an Excel program.

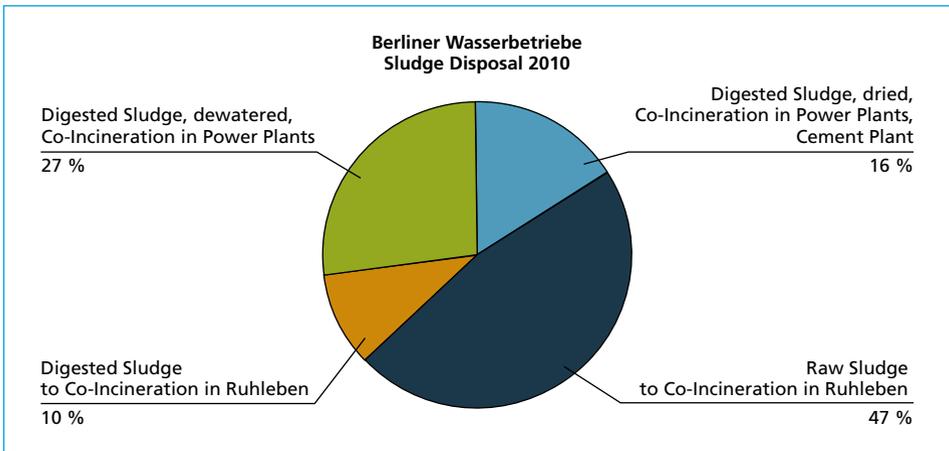


Figure 4: Disposal methods 2010

In total, a sludge volume (dry mass) of approx. 88,000 t was generated in all sewage treatment plants in 2010. The real distribution of the sludge volumes across the individual disposal methods is shown in the diagram in Figure 4. This distribution only differs slightly from the previously calculated, optimised distribution on the basis of cost minimisation.

#### 4. Use of the sludge treatment (material)

The generated sewage sludge is mechanically drained using centrifuges at all Berliner Wasserbetriebe sewage treatment plants. This reduces the sludge volume by a factor of

7 to 8. This reduction of the volume has advantages for the storage of sludge, as the storage silos can be significantly smaller and therefore more cost-effective.

For the disposal of drained sludge, the best-possible drainage results in lower costs, as less water is disposed of with it.

For drying, it also makes sense to drain the sewage sludge using centrifuges as much as possible prior to transferring it to the drying plant, as the mechanical drainage is more cost-effective than the thermal drying.

The same applies to the sludge incineration plant in the Ruhleben sewage treatment plant. Better mechanical drainage prior to submission for incineration also leads to a significant reduction of the backup fuel requirement (heating oil) and therefore to cost savings.

From the examples cited, it can be concluded that the dry mass content after the centrifuge plays an important role for the efficiency of the sludge treatment, generally even ahead of the costs for coagulant aids, electricity consumption of the centrifuges and investment costs.

In the literature on the subject of drainage, it is frequently stated that digested sludge can be drained better than raw sludge. The fact that this is not always the case is shown with the Berliner Wasserbetriebe sewage sludge. The raw sludge from the Ruhleben sewage treatment plant can be drained better and requires fewer coagulant aids than the digested sludge from the other sewage treatment plants.

The drying of the drained sludge leads to a further volume reduction with the advantages for storage and disposal, which are already mentioned above. However, whether the use of a drying plant is economical must be examined in the individual case, on the basis of the existing constraints, as the operation of a drying plant generates considerable costs.

The most extensive volume reduction of the sewage sludge is achieved with the incineration of the sludge in a sewage sludge mono-incineration plant, such as that in the Ruhleben sewage treatment plant. With this, only the ash is left over to be disposed of. For this, the efficiency must again be reviewed, which depends on the relevant constraints, e.g. sludge volume, heating value of the sludge, costs for alternative disposal.

In the Waßmannsdorf sewage treatment plant, another path is being taken in the material use of the sludge. Due to the biological phosphorous removal (Bio-P), there were problems due to residues of magnesium ammonium phosphate (MAP, also *Struvit*) in the pipelines.

This MAP is now being precipitated in a new process stage after digesting in a special tank, using magnesium chloride and compressed air, and recycled as fertiliser. With this, phosphorous is recycled from the sludge for use as fertiliser and at the same time, the pipelines to the digested sludge storage tanks and to the subsequent drainage in the centrifuges, as well as the central lines, are kept free from MAP and residues are thereby prevented.

## 5. Use of the sludge treatment (energy)

The mesophilic digestion of the sewage sludge, which is carried out in five out of the six sewage treatment plants operated by Berliner Wasserbetriebe, leads to a reduction of the organic sludge dry mass.

Through the reduction of the organic mass, sludge gas is produced from the digesting process. The generated sludge gas is used in all five sewage treatment plants, in combined heat and power plants (CHP) with gas motors for electricity and heat generation.

With this, approx. 50 to 60 % of the required electrical energy and nearly 100 % of the required heating energy can be provided for each of the sewage treatment plants.

The sewage sludge is not digested in the Ruhleben sewage treatment plant. Here, the higher heating value of the raw sewage is used to reduce the required quantity of heating oil for the backup firing. Due to the omission of digestion, the number of process stages is minimised for the sludge treatment.

After the incineration furnaces, waste heat boilers are arranged for each line, in which steam is generated. With the steam generated from the sludge incineration, a steam turbine is operated for generating electricity. With this, approx. 50 to 55 % of the electricity requirement for the entire sewage treatment plant can be generated.



Figure 5:

Steam turbines for electricity generation in the Ruhleben sewage treatment plant

Alternatively, the steam can be used in turbo superchargers to generate air for the activated sludge tanks. However, this use of steam is not as efficient as the conversion into electricity, as unnecessary excess ventilation frequently occurs with this method. Therefore, the turbo superchargers are only used in an emergency (no other use of steam possible or not air generation possible using electric supercharger).

## 6. Summary

The mechanical sewage sludge drainage is a minimum treatment level for sludge treatment in large cities, as the sludge can generally not, or not entirely, be transferred to agricultural recycling due to the high pollution and the large quantity.

Further treatment of the sewage sludge in the form of drying and/or incineration must be examined in the individual case, with regard to efficiency and disposal safety.

With this, regional options for the disposal of drained or dried sludge frequently play a role and influence the decision regarding whether the sewage sludge should be transferred externally for disposal or should be disposed of in own sludge treatment plants.

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