STADTENTWÄSSERUNG MANNHEIM

Remit and organisation

The remit of Eigenbetrieb Stadtentwässerung Mannheim (EBS) is to collect dirty water from private homes and industry, plus the rainwater across the whole Mannheim area, then to treat it and return it to the natural water cycle via the Rhine receiving water course. In this way, EBS fulfils its obligation to remove wastewater for the City of Mannheim. It does this based on the principle of preventive health care for the city's population and to provide maximum possible protection for people and the environment.

As an owner-operated municipal enterprise, EBS is assigned to the Department for Local Services, Climate, Environmental Protection and Technical Services. Its supervisory body on the municipal council is the Technical Services committee. The supervisory authorities are the Karlsruhe Regional Council (as the higher water authority) and the Climate, Nature, Environment department of the City of Mannheim (as the lower water authority). These check and support compliance with the statutory requirements. At EBS, the Wastewater Chemistry department has the particular task of self-auditing the pollutant limits in the wastewater at the treatment plant. The Wastewater Chemistry department is also approved as an expert body for the water management industry.

Environmental guidelines

EBS has been certified to the ISO 9001 and ISO 14001 quality and environmental standards since 2003. Occupational health and safety and health protection are integral components of the environment and quality management system. As critical infrastructure, EBS is also subject to the KRITIS regulations issued by the Federal Office for Information Security (BSI). As a municipal provider of environmental services, EBS has defined as mandatory a range of environmental guidelines. These include protection of natural resources and the environment through the use of environmentally-friendly methods and optimised use of equipment, reduction of emissions and wastes, protection of the groundwater with rainwater infiltration systems and advising customers on the need for leak-free drains on their property and backflow prevention.

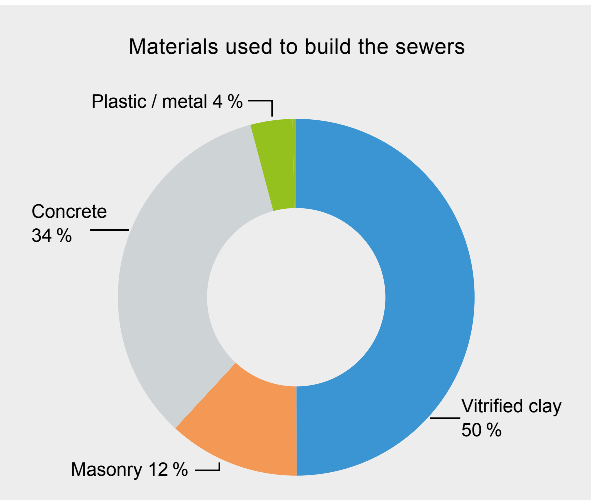
Environmental goals

The most important long-term goals include water pollution control (use of the 4th purification stage, rainwater infiltration) and reduced use of energy from external sources in order to make the wastewater treatment plant "energy self-sufficient" in the near future. EBS is thus making a significant contribution to the City of Mannheim's climate protection concept. As part of its quality and environmental management system, every year EBS draws up a programme setting out its environmental and quality goals and the associated actions. The goals relate to the system of desired outcomes that was introduced in 2009 as part of a change process for all services provided by the City of Mannheim. EBS regularly evaluates the extent to which it has attained these goals with reference to key indicators and the actions undertaken.

WASTEWATER DISCHARGE

The sewer system
The City of Mannheim's sewer system consists of wastewater and rainwater drains. It does not include the pipes on private property. The EBS primarily operates a combined sewer system, i.e. dirty water and rainwater are drained together. The sewer system within EBS's area of responsibility currently extends to 837 km.

Cleaning and inspection
To keep the sewer system in good working order, the sewers are cleaned at regular intervals, generally every two years. In line with Baden-Württemberg's self-auditing regulation, EBS regularly checks the condition of the public wastewater sewers. Recording the condition of the sewers by surveying and camera inspection provides the basis for ensuring that the system is working safely. This data is collected by inspecting the sewers with a camera and then compiled in a sewer database.



Up to 2019, around 94.3 % of the sewers had been inspected digitally with the TV camera. The inspection interval for the sewers is between 12 and 15 years.

Various types of material have been used to build Mannheim's sewer system. Vitrified clay is primarily used for smaller sewers with a diameter of 250 to 800 mm. This material has been in use for decades, so 406 km of glazed clay pipes represents almost half of the sewer system. Concrete was generally used for larger profiles (in excess of 1000 mm diameter), and currently represents 276 km of sewer. Masonry using kiln-fired bricks was often used in the past, and there are still 100 km of such sewers. At present, 31 km of sewer is built from other materials such as plastic or polymer concrete.

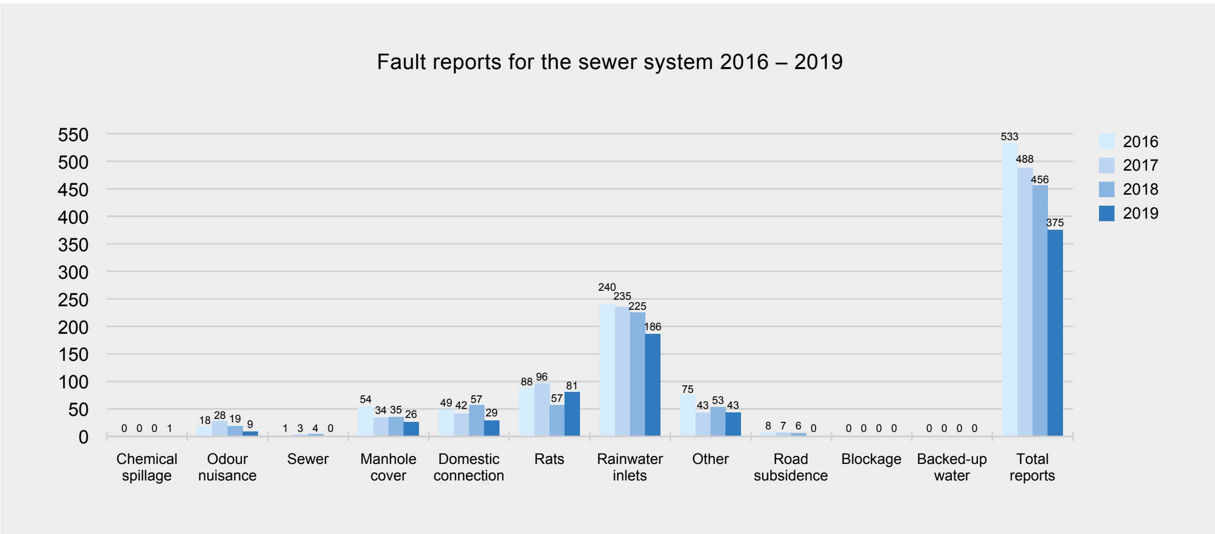
Sewer repair
The condition of the sewers is recorded with the TV camera; if there is any damage, an appropriate repair schedule can be drawn up. This ranges from one-off repairs by excavating an open trench, robot and inline measures through to complete sewer replacements either in open trenches or in closed galleries. Localised damage that does not affect the entire reach (sewer between two shafts) is repaired either by robots or manually in accessible sewers, or by excavating localised trenches.

The following repairs and replacements took place in the sewer system in 2019:

- 405 robot repairs 18.7 km
- Sewer repairs (construction crew) 5.8 km
- 79 localised trench excavations 3.8 km
- Inline repairs 2.6 km
- Sewer replacements 0.5 km

Customer service and complaint handling

Since 2002 EBS has provided a continuous complaint handling service. Reports of faults in the sewer system from residents, police, fire service or municipal agencies are immediately forwarded to sewer operations, are checked locally by the appropriate employee and remedied at the first possible opportunity. All important fault data and the actions carried out are documented in the customer service report.



This report reflects the various events such as more extensive structural measures or extreme weather conditions in the previous year. Since 2016, the number of call-outs due to faulty or blocked rainwater inlets or faulty domestic connections has fallen slightly, possibly on account of the lower rainfall. The complaints concerning odour nuisance and rats vary. Overall, however, fault reports have shown a downward trend for the period from 2016 to 2019.

Land drainage
It is the property owner who is responsible for maintenance and repair of private domestic connections. According to the wastewater regulations of the City of Mannheim, responsibility for private wastewater systems extends beyond the property boundary to the connection to the city's sewer.

If contaminated water leaks out due to leaking or damaged connecting pipes, this can cause public areas to be eroded and undermined as well as contaminating the groundwater. It often results in potholes in the pavement or road.

Rainwater infiltration
Up to a few years ago, most of the rainwater in cities was routed into the sewer by the shortest route. This has resulted in a continuous lowering of the groundwater level, especially in dry years. One requirement of the European Water Framework Directive (WRRL) is to give priority to rainwater infiltration. Accordingly, in new builds, §55 (2) of the Water Resources Act requires the rainwater on the property to be infiltrated. The objective of rainwater infiltration is to restore the natural equilibrium of the water cycle and promote raising of the groundwater levels.

Where the ground surface is sealed, heavy rainfall events increase the risk of flooding on roads and squares since the sewer system is unable to absorb large volumes of rain in a short time. For this reason, more space needs to be created for rainwater storage in cities. With joined-up planning, such as the concept of the "sponge city", municipalities will be able to reduce the impact of heatwaves on their residents in the long-term. And unsealing surfaces such as school playgrounds along with the construction of infiltration systems are making a significant contribution to improving the city's climate. In recent years, EBS has implemented various projects for decentralised rainwater infiltration in public spaces. In the course of developing and replacing the wastewater system in the Hochwald, Krautgartenweg, Schlehenweg, Donar- und Neueichwaldstraße area, infiltration swales and channels were installed in public green spaces and roads.

The positive effect of relieving the pressure on the sewer system during periods of heavy rainfall is that flooding and backflow on the roads is a much rarer occurrence. In new housing developments, EBS can compensate for reduced drainage by the wastewater sewers through the use of improved pipe materials. In contrast to the old brick or concrete sewers with their rough surfaces, the new wastewater sewers made from HDPE (High Density PolyEthylene) are smoother, so fewer deposits are able to adhere to them.

CO_2-neutral heat from wastewater
EBS operates two systems for using wastewater heat to heat buildings. The Ochsenpferch pumping station has been heated with wastewater heat since 2011, saving several thousand litres of heating oil every year. The system in the EBS office building in Käfertaler Straße came into operation in 2013. After an interruption due to installation of a new heat exchanger in the sewer, the system has been heating and cooling since 2015.

The Marchivum in the former wartime "high-rise" air-raid shelter, the Ochsenpferch Hochbunker, also uses wastewater heat. In 2017 with support from EBS, a heat exchanger was installed in the inlet sewer to the Ochsenpferch pumping station and a pipe was laid as far as the building's connection point.

The table shows the outputs of the systems for the Ochsenpferch pumping station, the EBS office and staff facilities building and the Marchivum. The heat exchanger for the Marchivum was connected up in the course of 2018. By using wastewater heat, up to 500 tonnes of CO_2 emissions have been avoided every year.

Wastewater heat within the city area

2016	241,700 kWh
2017	331,000 kWh
2018	566,200 kWh
2019	840,300 kWh

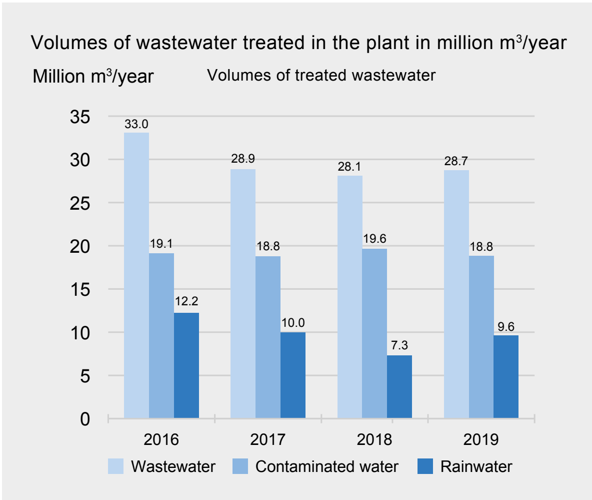
WASTEWATER TREATMENT

The treatment plant
Every day, the central treatment plant in the north of Sandhofen purifies on average 89,000 m³ wastewater from homes, industry and businesses across the entire city area. It was designed for a PE (population equivalent) of 725,000.

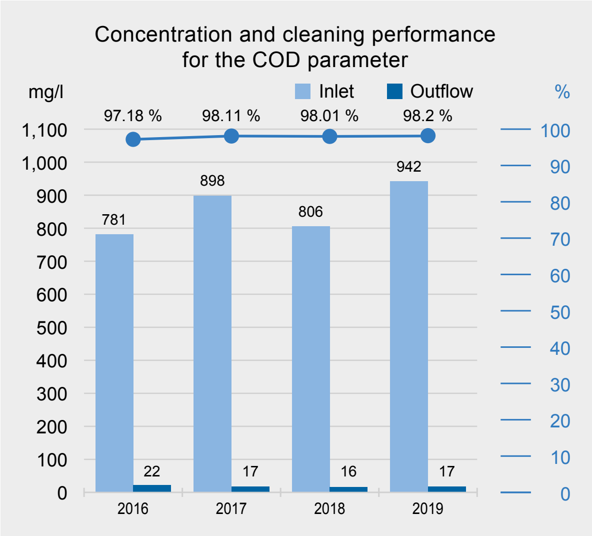
Method
Within 24 hours at the treatment plant, the wastewater passes through multiple stages where it is purified and filtered before being routed into the Rhine receiving water course.

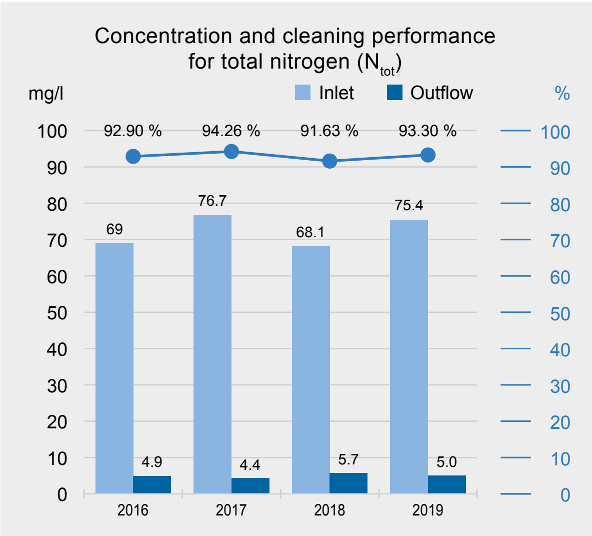
- Mechanical wastewater treatment with coarse and fine screens, sand trap, aerated grease trap and preliminary clarifier
- Biological wastewater treatment with nitrification, denitrification and biological phosphorus elimination in the activated sludge tanks, plus secondary clarifier
- Chemical wastewater treatment (as a complementary treatment only) by the addition of iron salts to eliminate phosphorus
- Flocculation precipitation in three layers with gravel, sand, expanded shale and granulated activated charcoal (GAC)
- 92% of the wastewater passes through the powdered activated carbon (PAC) system to eliminate micro-pollutants. This is the 4th purification stage.

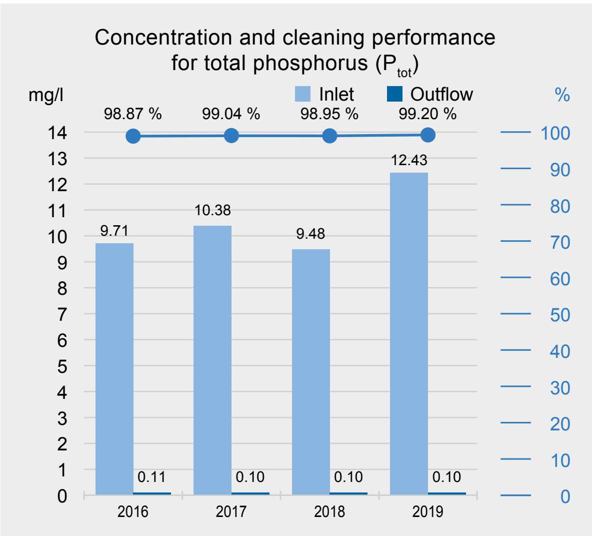
Environmental performance
At EBS, the environmental performance relates primarily to the measurable results for purification by the treatment plant. By examining the environmental and approval-related parameters – COD (chemical oxygen demand), total nitrogen (inorganic) and total phosphorus – the elimination rate is determined from the difference between the nutrient and contaminant content in the wastewater at the inlet and at the outflow. The elimination rate is the most important indicator for effective water pollution control.



In the DWA's comparison of performance for Baden-Württemberg in 2019, the EBS repeatedly obtained the top rating for the rate of elimination of each pollution load. And with respect to the external water entering the sewer system, Mannheim again clearly won top place with just 1.0%. This documents the above-average condition of the sewer system. The performance of 887 treatment plants of all size classes is compared every year; the comparison is mandatory for all wastewater treatment companies.







Elimination of micropollutants with activated charcoal

Powdered activated carbon (PA) is used in the 4th purification stage to remove micropollutants from the wastewater. These are trace substances that can have a negative impact on the aquatic environment and are very difficult to eliminate. They are primarily the active ingredients of drugs, along with household and industrial chemicals. In the PAC system, the powdered activated carbon is added to biologically purified wastewater. The trace substances are deposited on the surface of the PAC. Once the charged PAC has been removed, it settles as sludge with the addition of small amounts of precipitating and flocculating agents. The wastewater passes through the filtration system in order to remove the remaining PAC and is thus optimally purified when it is sent to the Rhine receiving water course.

Granulated activated charcoal (GAC) is used in large quantities for filtration. As a trial, in 2018 three filters (subsequently eight and eventually 16 filters) were retrofitted with GAC so that they could remove the large quantities of micropollutants that are carried in the wastewater during heavy rainfall.

Removal of microplastics

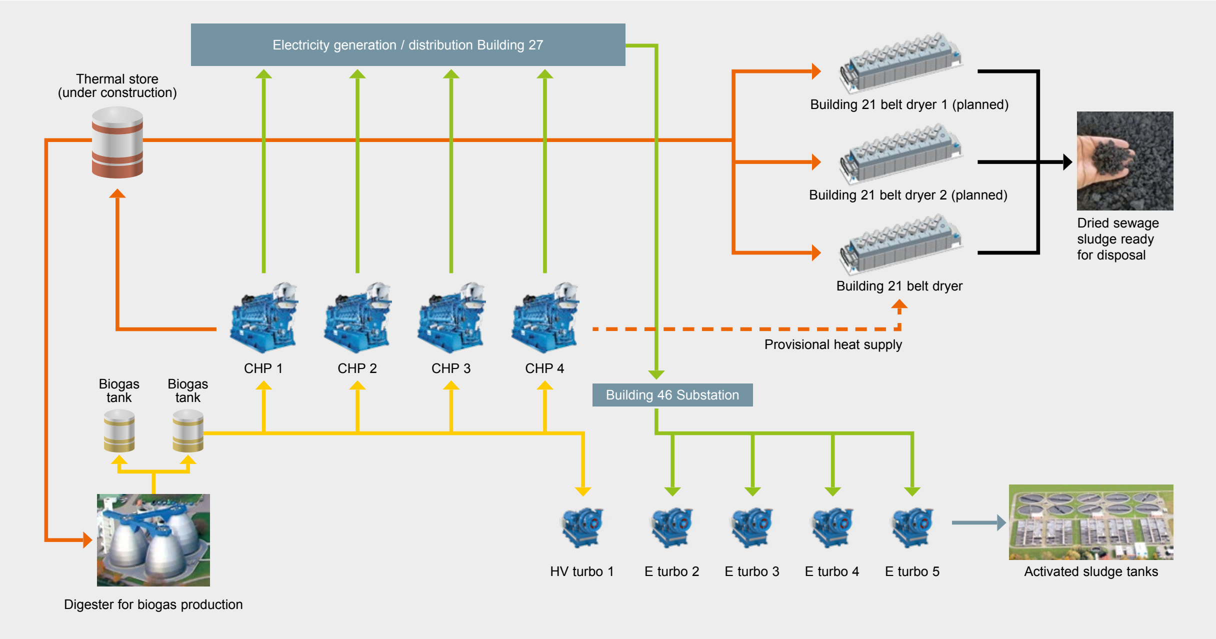
Microplastics are plastic particles that are smaller than 5 mm and can barely be seen with the naked eye. There are two types of microplastic: The basic beads are classified as “primary microplastics”. They include beads in cosmetics and personal care products such as peels, toothpaste, handwashes, along with microscopically small particles such as the plastic fibres in fleece clothing.

Secondary microplastics are created by the physical, biological or chemical breakdown of macroplastics, such as the decomposition of plastic bags when exposed to sunlight or tyre wear particles from road vehicles. In terms of quantity, these tyre wear particles represent a significant proportion of the microplastics in Germany.

The flow of wastewater carries considerable quantities of microplastics into the treatment plant. Most of the microplastics are removed and bound up in the sewage sludge as the wastewater passes through the individual purification stages (screening, preliminary sedimentation, biological treatment, secondary sedimentation, 4th purification stage and filtration). In particular, the filtration at the Mannheim treatment plant ensures that even the tiniest microplastic particles are almost entirely removed from the flow of wastewater. This has been confirmed by the latest analyses for microplastics carried out by Darmstadt Technical University and the Water Technology Centre in Karlsruhe.

Sludge treatment

Wastewater treatment creates some 10,000 tonnes of dried sewage sludge every year. The volume of the watery sludge is reduced in a series of steps, creating dried granules as the end product.



- Sludge treatment by pre-thickening with centrifuges, i.e. removal of a large part of the sludgy water
- Transfer of the sludge to three digesters where it remains for 35-40 days under the exclusion of air and at a constant 37 °C
- Dewatering of the digested sludge, reduction of the water content from 94 % to around 75 %
- Thermal drying to a residual moisture content of 5 %

Most of the dried sewage sludge pellets are used in the cement industry for generating heat and as a material.

Phosphorus recovery

The amended sewage sludge regulations will require treatment plants designed for a population equivalent of 100,000 to incorporate phosphorus recovery facilities from 2029 onwards. EBS will decide by 2023 where it will send its dried sewage sludge for phosphorus recycling in the future.

Energy management

To reduce rising energy costs, EBS is making increasing use of renewable energy generated by its own systems. Sewage sludge digestion currently generates around 9 million m^3 biogas every year. This is converted into electricity and heat via gas engines in combined heat and power (CHP) systems. The gas engine heat thus obtained together with the surplus heat from the sludge dryers provides all the heat that the treatment plant needs to heat the digesters and buildings and to supply hot water. At the same time, the gas engines in the CHP system provide the emergency power supply to parts of the treatment plant so that the flow of wastewater through the treatment plant can be maintained during sustained power outages.

Since the cost of natural gas has only risen slightly compared to electricity prices, the biogas is primarily used to generate power. For this reason, natural gas is being used more often to supplement the generated biogas for drying sludge. It is intended that all the biogas will be used to generate power in the future, while the surplus heat from the CHP system (via the thermal store) will be used for the belt dryers in the new sludge drying plant. This is another milestone on the road to the “energy self-sufficient” wastewater treatment plant.

Cofermentation

In the cofermentation process, product residues from the food industry or other readily degradable organic substances are combined with the sewage sludge in the digesters. These augmented digestion processes have greatly increased the biogas production. For EBS, cofermentation is a fixed component of the energy management system since it increases the production of electricity and heat.

Energy optimisation

The increased use of biogas produced in-house to generate electricity and heat goes hand-in-hand with the reduction of CO_2 emissions. The most important measures include renewal of the sewage sludge drying system, replacement of the CHP system motors and construction of a thermal store. In 2019, biogas generation, heat utilisation and energy-saving measures, along with the operation of a PV system and waterwheel, allowed some 34,000 tonnes of CO_2 emissions to be avoided. Around 60 percent of the treatment plant’s total power consumption was self-generated.

ENVIRONMENTAL BALANCE

The activities and methods associated with wastewater collection and treatment inevitably have some impact on the environment. On the one hand there is the consumption of water, energy and materials, while on the other hand they also create wastes and other residual substances. Examination of the flows and quantities of materials provides the data needed to establish measures for reducing the environmental effects.

EBS works hard to minimise its consumption of resources such as extraction of groundwater or the purchase of external electricity. The quantities of waste resulting from the wastewater treatment, sewer cleaning and sewer repair are (where possible) reduced and sent for recycling. One example of this is the use of purified wastewater as process water. However, viewed overall, the environmental impact of wastewater collection and treatment appears relatively small when compared to the benefits of the sewer system and treatment plant for the health of the population and for the environment.

And any examination of the environmental balance must also consider the economic aspect. For a range of measures it can be seen that investment in environment and climate protection will pay off in the long-term; these measures include energy optimisation with the objective of creating an "energy self-sufficient" wastewater treatment plant.

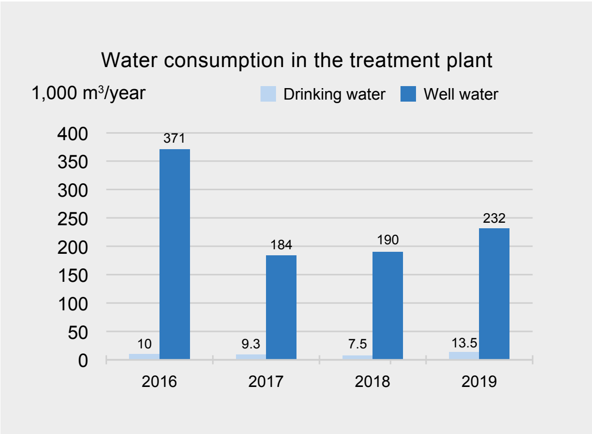
Consumption of resources

Water

Most of the drinking water consumed in the sewer operation is used to flush the sewer pipes. This drinking water consumption can be reduced through the use of three high-pressure sewer flusher trucks with water recovery. However, this resource-saving technology can only be used with sewer pipes with a diameter of more than 1 m, and there also needs to be a sufficient inflow of wastewater.

The treatment plant obtains most of its water from groundwater (which is extracted via two wells and five pumps) and by using purified wastewater. Some of the purified wastewater – 2.5 million m³ on average every year – is used in the treatment plant as process water in the following systems:

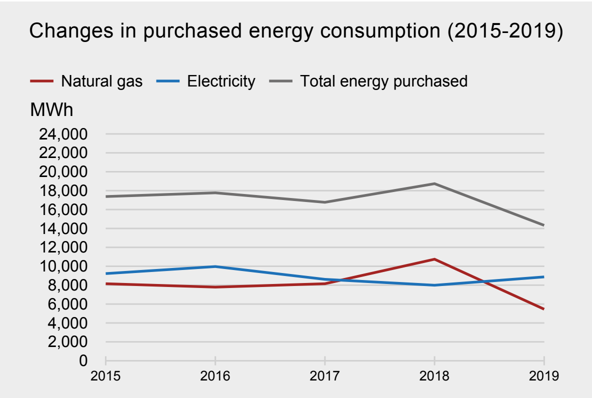
- as cooling water in the sludge dryer
- for flushing the filters in the wastewater filtration system
- in the sand washing system (replacing well water)
- for flushing the rainwater overflow tanks in the treatment plant
- to supply the flocculant station in the PAC system (4th purification stage)

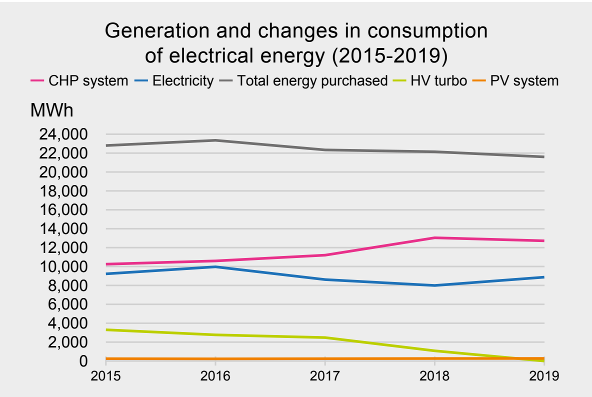


The sharp rise in drinking water consumption in 2019 is explained by the fact that the old flocculant station for dewatering the sewage sludge only had a drinking water connection. From 2021 onwards, the new flocculant station will be supplied with treated wastewater.

Energy – electricity and natural gas

Changes in energy consumption at the treatment plant should be considered in conjunction with the measures to in-house generation measures.



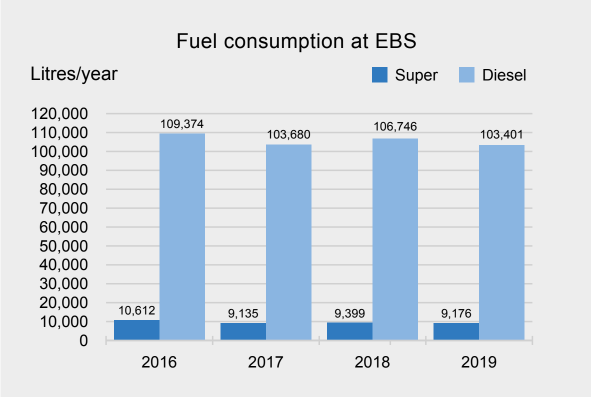


The increased natural gas procurement in 2018 was due to the replacement of biogas with natural gas in the HV turbo air compressor and in the sludge dryer. The high electricity price meant that biogas was used increasingly to generate electricity. In this respect, natural gas as a fuel for the CHP system and HV turbo continues to be important both technically and financially. In 2019 the HV turbo failed completely, so the power consumption for the other air compressors increased. The increased power consumption in 2019 is attributable to the increase in construction and repair activities at the treatment plant. Even though other generators and systems have been brought into service at the treatment plant, the energy requirement dropped sharply in 2019.

Operating materials

Fuels

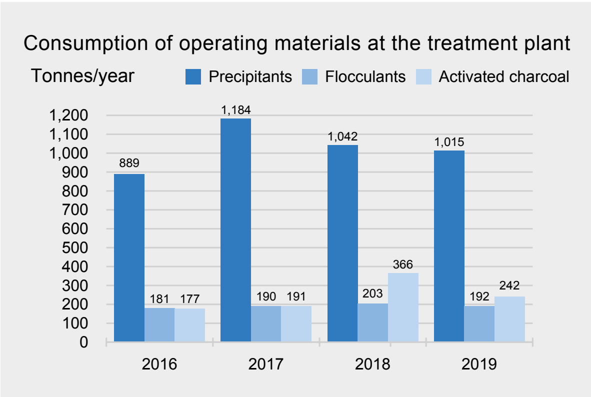
The largest part of the total fuel consumption (petrol and diesel) is attributable to the service vehicles used in the



sewer system. The high pressure flusher and suction vehicles drive powerful generators with diesel engines, so their fuel consumption is relatively high. The recently purchased vehicles are less energy-hungry and conform to the latest Euro-6 standard. Some of the sprinters are equipped with hybrid electric engines.

The other fuels – petrol or super – are used for day-to-day business mileage in the company's cars. At the treatment plant, there is a natural gas-powered vehicle for courier/transport services or business travel. The planned purchase of electric compact cars (funded by the Baden-Württemberg Environment Department) will greatly reduce petrol consumption.

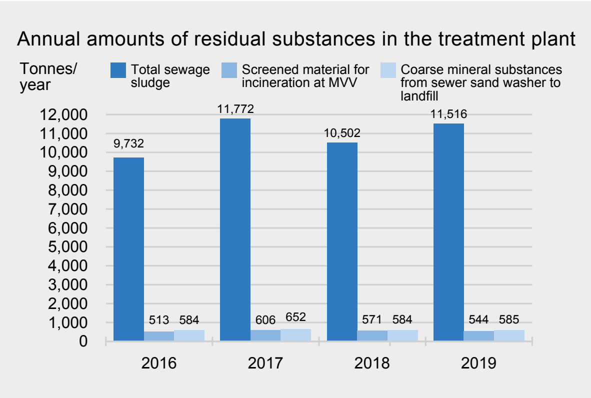
Precipitation and flocculation additives



The use of precipitants and flocculants helps to improve the wastewater and sludge treatment processes. The amount used each year in the biological stage is highly dependent on the weather. In winter, it is especially necessary to add iron sulphate-based precipitants to eliminate phosphates from the wastewater. In summer, on the other hand, only small quantities are needed to remain within the set limits. For sludge treatment, flocculants are added in the same quantities all year round. They are used to thicken and dewater the sewage sludge. The additive helps the sludge flocs to increase in volume so that the water can be better reduced.

Activated charcoal
Since 2016, EBS has been running a powdered activated carbon system in the treatment plant. This further treats up to 1,500 litres per second (l/s) of purified wastewater using powdered activated carbon. In 2019, the flow rate was increased from 1,500 l/s to a maximum of 2,000 l/s. Trials with granulated activated charcoal in the filtration system showed that, even in periods of heavy rainfall, trace substances in the rainwater that is partly diverted around the PAC system in a bypass pipe can also be removed using activated charcoal.

Residual substances



Sewage sludge and screened material
Since 2005, the dried sewage sludge has been primarily used as a fuel in the cement industry. The total amount of sewage sludge has risen slightly due to the cofermentation system, but was relatively stable at around 10,000 tonnes per year. The systems in the sludge drying plant suffer from frequent stoppages as it has been in operation for 25 years. As a consequence, more dewatered sewage sludge has had to be transported away for external disposal.

The increased amounts of screened material are attributable to the increased occurrence of waste on the public roads and to cleaning wipes in the incoming wastewater. Screen material means all wastes that are removed from the wastewater using large screens.

Treatment and sewer sand
Large amounts of sand are produced during wastewater treatment at the plant and when flushing the sewer pipes. The sewer sand that reaches the treatment plant and the sand from the sand trap goes into the sand washing system. Here the organic components are removed. The sulphate content of the washed sand is too high, so it cannot be used by the sewer construction companies.

The washed sand is taken to the AGB Mannheim landfill site where it is used as a covering material.

Considering the environment is daily routine
On the way to being climate-friendly
One potential area for saving on fossil fuels and thus CO_2 emissions is the field of mobility. The use of bicycles and electric cars for business travel, call-outs and especially to and from work is paying dividends. There are some 100 company bicycles available for employees to speed around the large wastewater treatment plant. These are maintained by one employee alongside his work at the treatment plant. For business travel by administrative staff at Käfertaler Straße there are two city bikes and one pedelec available for short distances. There are currently eight electric cars in use at the treatment plant. Two of these are used around the clock by process engineering staff working in shifts. Three electric cars are stationed in the metalworking shop, and two in the electrical, instrumentation and control department. They are used to transport tools and heavy spare parts such as pumps, generators, etc. One electric car is used every day to transport materials for cleaning various buildings or pumping stations and to carry paper for recycling and other wastes.

The range of the electric cars depends on the time of year, the terrain, driving style and the loading, but it is in the region of 65 km. The highest speed is 29 km/h with a maximum noise level of 62 decibels. They can be charged at any 230 V socket. The vehicles are regularly charged overnight. Under normal conditions, one charge will last three days.

Biotope at the treatment plant
The Mannheim wastewater treatment plant is located in the middle of a conservation area. By caring for nature, EBS endeavours to meet the needs of this special location. Several meadow orchards and ponds, plus the trees and shrubs planted around the treatment plant, provide a rich habitat for numerous animal and plant species; this type of planting is rarely encountered in the intensively cultivated agricultural landscape of the Upper Rhine. The grassed areas kept in reserve for possible future expansion of the wastewater treatment systems are grazed by a flock of sheep. The meadows with their many edible wild herbs and the variegated sandstone dry-stone walls (remnants of Mannheim's old castle) also encourage species diversity at the treatment plant.



EBS IN FIGURES – 2020

General data	
Drainage area	City area of Mannheim
Surface area	145 km²
Number of residents (9-2020)	324,233 residents
Connected residents	99.9 %
Number of employees	260
Trainees	8
Wastewater charges – from 1 January 2021	
Contaminated water charge.	1.68 €/m³
Rainwater charge.	0.80 €/m² per year
Wastewater discharge	
Drained areas	approx. 7,100 ha
Length of sewers in EBS's area of responsibility (combined sewer system)	837 km
Operational vehicles	
- Cleaning vehicles (suction/flusher vehicles, three with water recovery)	6
- TV vehicles	3
Pumping stations and rainwater overflow structures	
Rainwater overflow tanks (ROT)	8
Rainwater retention basins (RRB)	8
Storage sewers	12
Rainwater infiltration systems	2
Total retention volume	170,000 m³
Pumping stations	39
Lifting systems	32
Wastewater treatment and treatment plant	
Population equivalents	725,000 Pe
Incoming volume in dry weather (2019)	approx. 89,000 m³ per day

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