Clean into the Rhine

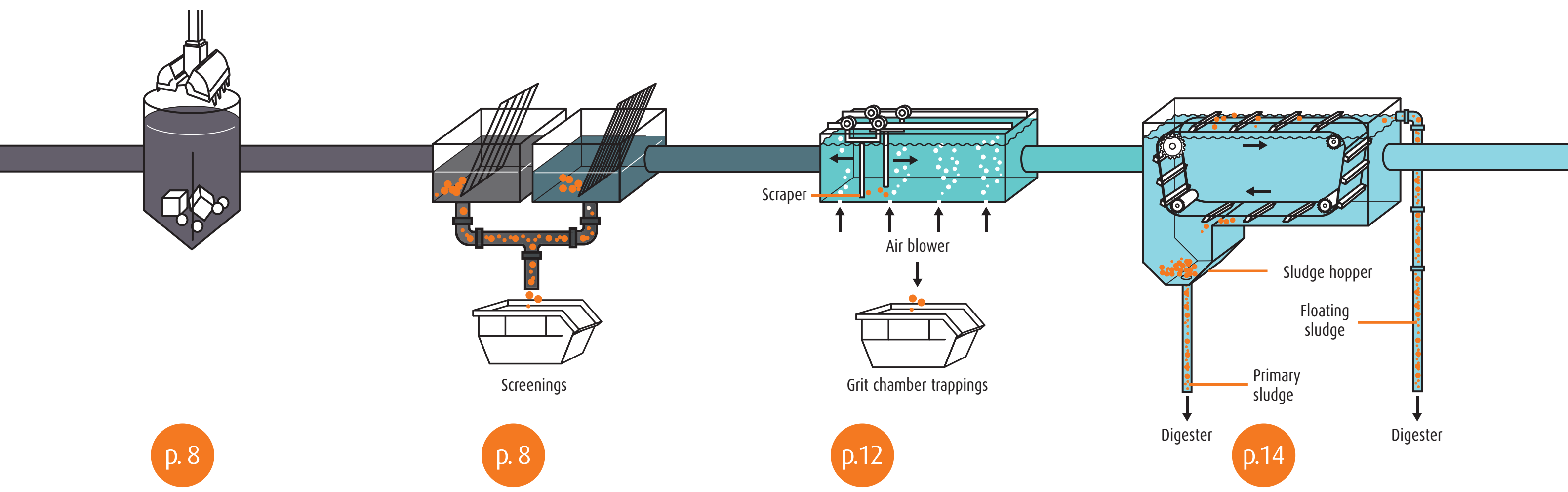
MAIN WASTEWATER TREATMENT PLANT WIESBADEN

ELW

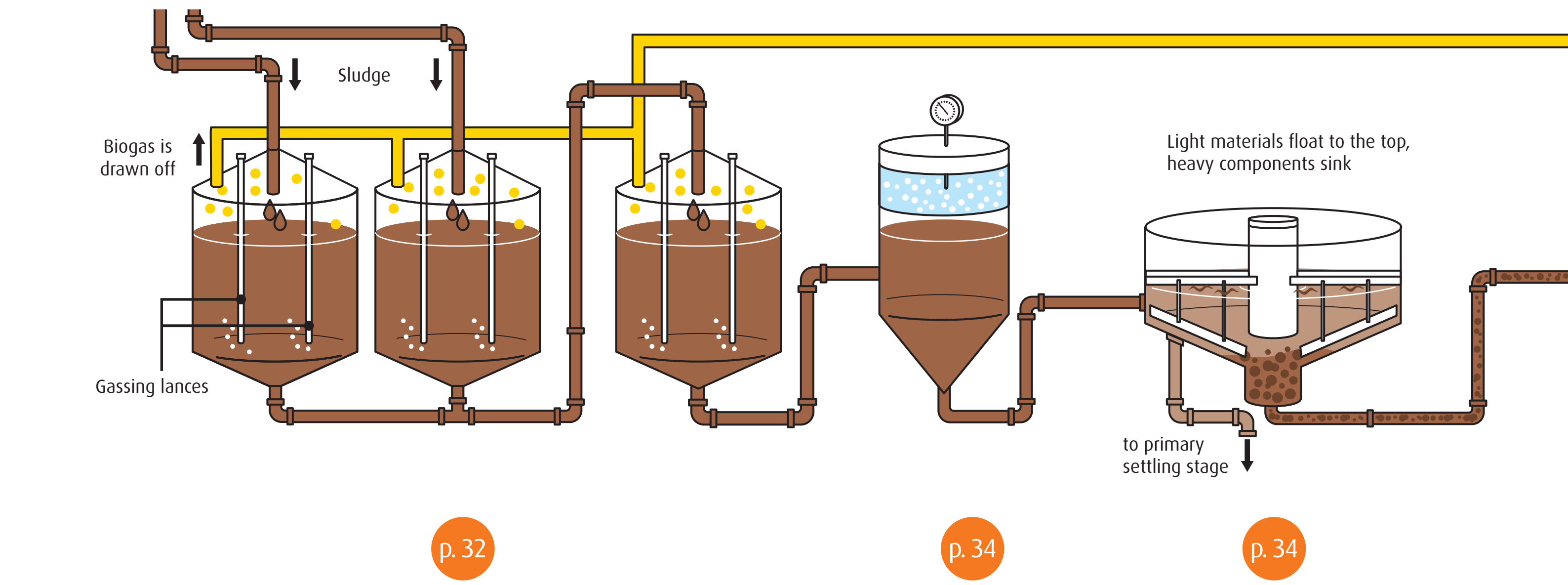
The stations of the main wastewater treatment plant in overview

MECHANICAL TREATMENT

Debris trap	Coarse and fine screens	Aerated grit chamber	Primary settling tank

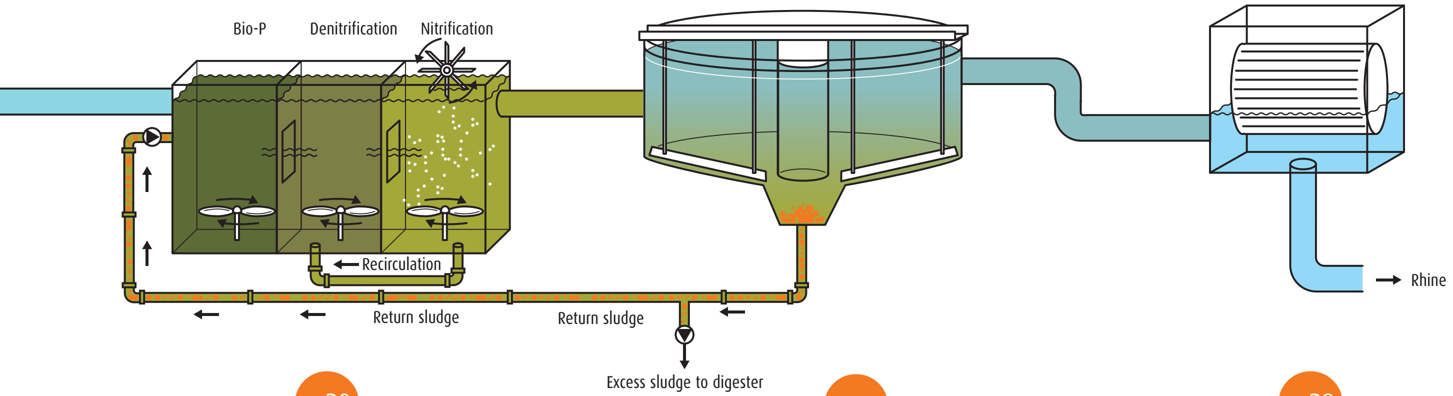


Digesters	Vacuum degassing	Post thickener



BIOLOGICAL TREATMENT

Aeration tanks | Secondary settling tank | Microstrainer plant



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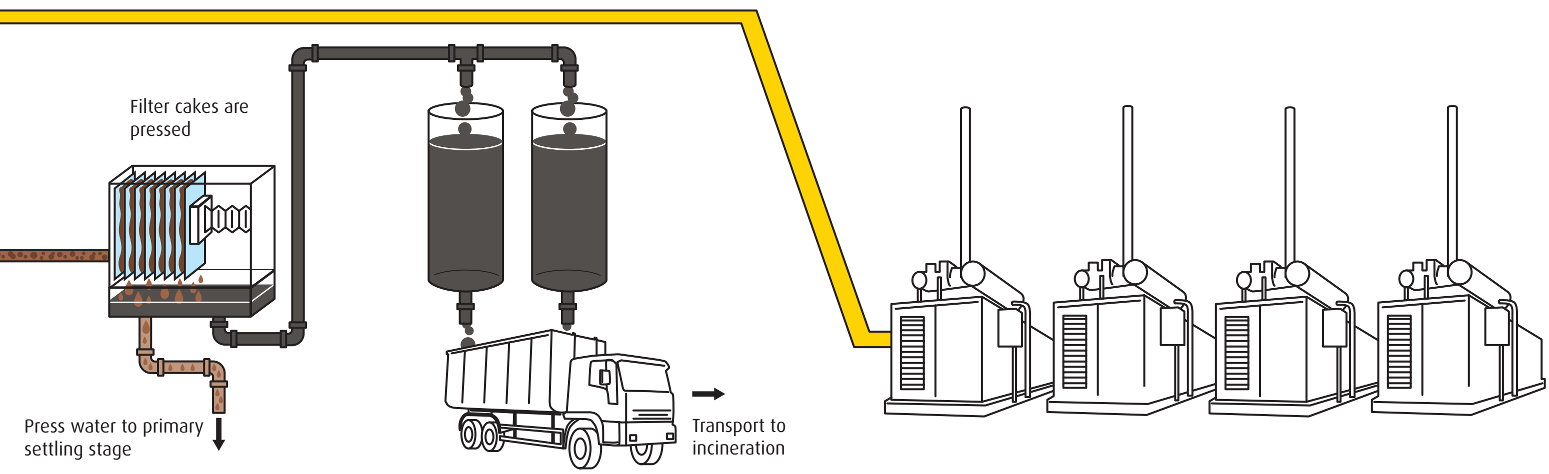
Chamber filter press | Silos | Combined heat and power units



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Michael Haeusler
Division Manager Drainage and Treatment, ELW

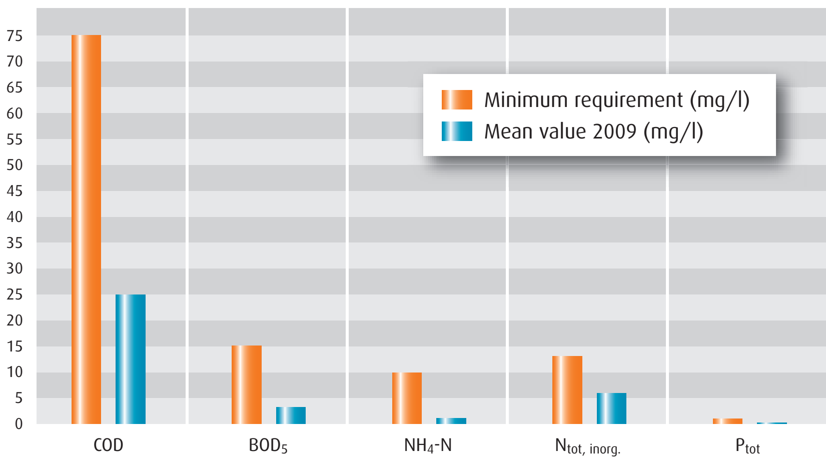
Today, no one would doubt any longer that water is a valuable resource which must be dealt with carefully. The adage "If the river dies, people die" emphasizes our responsibility if one thinks that Wiesbaden draws its drinking water to 30% from groundwater enriched with Rhine water.

In Wiesbaden, this responsibility was faced up to at a very early date. For over 100 years, treatment of wastewater has been carried out according to the state-of-the-art at the site of today's main wastewater treatment plant. In doing so, the facility has been repeatedly matched to the new requirements. With this, we have significantly contributed to the fact that the Rhine in the past decades has been able to develop again into a clean river with functioning eco-system. While its water quality in the area Wiesbaden/Rheingau still occupied Quality IV in a scale from I to IV in 1970, since 2006 it has been continuously Quality II.

Currently, we are involved with trace elements from human wastes such as the remains of medicines and hormones which today pass through our wastewater treatment plants almost unhindered but prejudice the fish stocks and the quality of the drinking water. Within the foreseeable future, however, we will have technologies even to reduce this loading significantly.

We stay on the ball. Does this make you curious? Then read on.

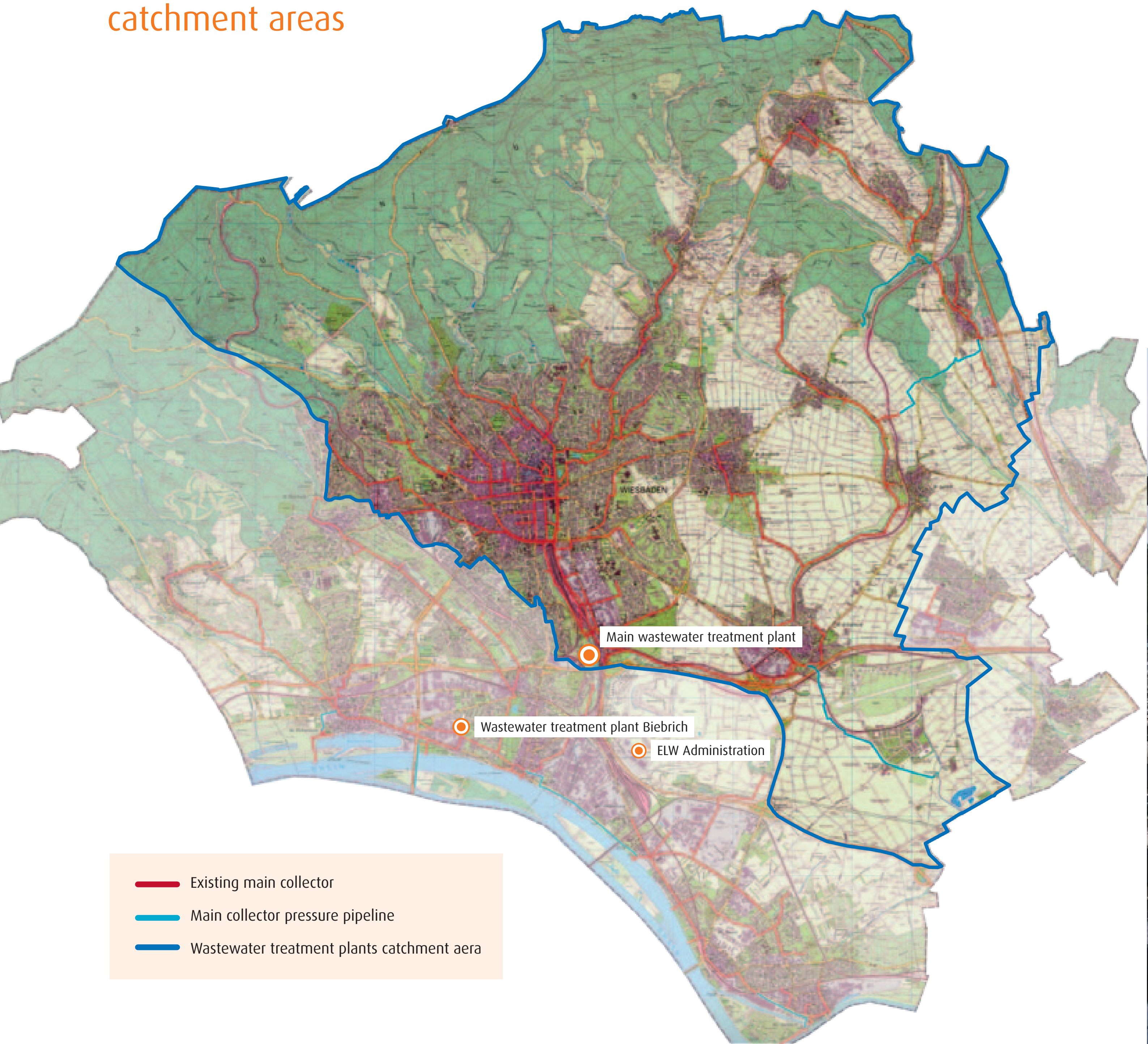
COMPARISON MINIMUM REQUIREMENT AND MAIN WASTEWATER TREATMENT PLANT DISCHARGE VALUES 2009



1 Screening chamber
2 Grit chamber
3 Primary settling stage
4 Biological treatment
5 Secondary settling stage
6 Microstrainer plant
7 Control center
8 Digesters
9 Post thickeners
10 Sludge dewatering
11 Sludge silo
12 Combined heat and power units
13 Administrative building
14 Machine workshop
15 Electrical workshop
16 Works laboratory

» SEWER NETWORK WIESBADEN

Overview of the wastewater treatment plants catchment areas



On average, almost 50 million liters of wastewater flow through the Wiesbaden sewer system to the main wastewater treatment plant each day. In part this originates from 190,000 inhabitants; a further large part comes from commerce and industry. The total loading of the facility lies at 250,000 population equivalents (PE). With an expansion capacity of 325,000 PE it still offers scope for further urban development measures.

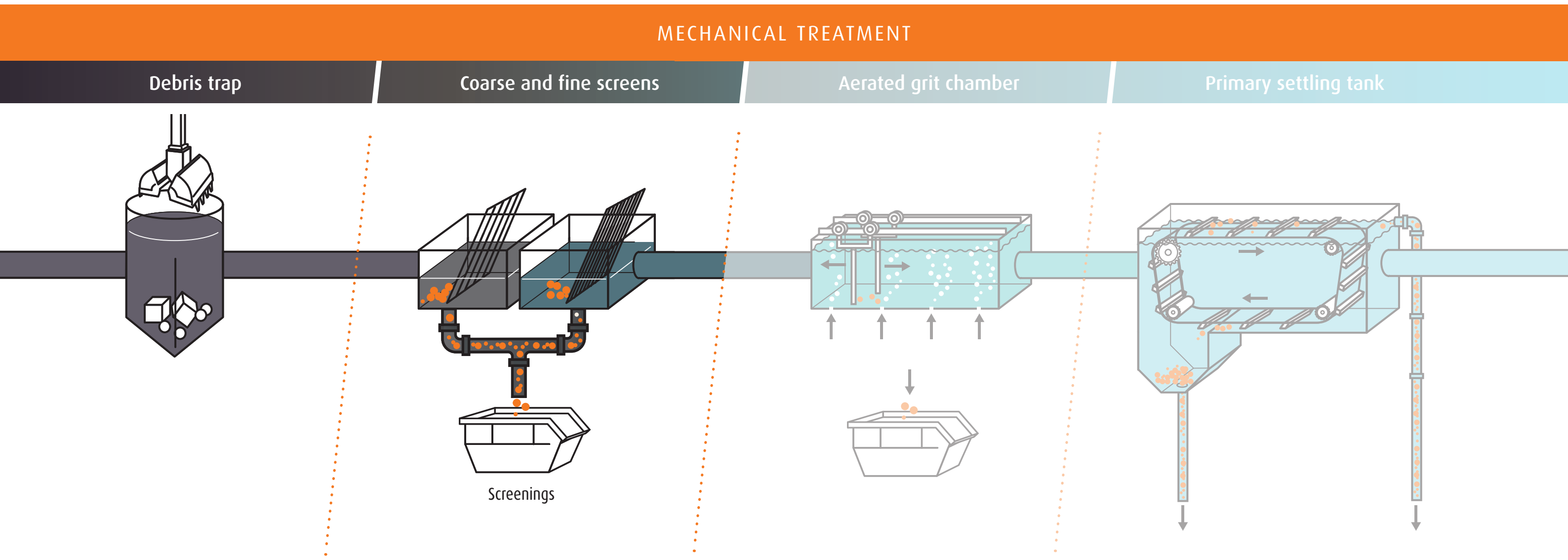
In the main wastewater treatment plant a team of some 70 employees are in action around the clock in order, on one hand, to treat the wastewater and, on the other, to treat and dispose the thereby resultant sludge.

We would be happy to show you how we do this. Take a look behind the scenes.

The path of the water

With the treatment of wastewater in the Wiesbaden main wastewater treatment plant, we resort exclusively to procedures which also take place in nature. As these processes, however, run significantly more efficient under optimized conditions than in nature, the wastewater flows so clean into the Rhine already after a retention time of ca. 1.5 days in the treatment works, that legally specified boundary limits are well undercut.

The wastewater stream is by no means even; with heavy rainfall it increases significantly. In the short-term, the treatment works can process up to three times the daily acceptance quantity. With even greater amounts of wastewater we regulate the inflow via sewer storage capacity, storm-water holding tanks and pump stations.



» DEBRIS TRAP AND SCREENING CHAMBER

Three lots of screening

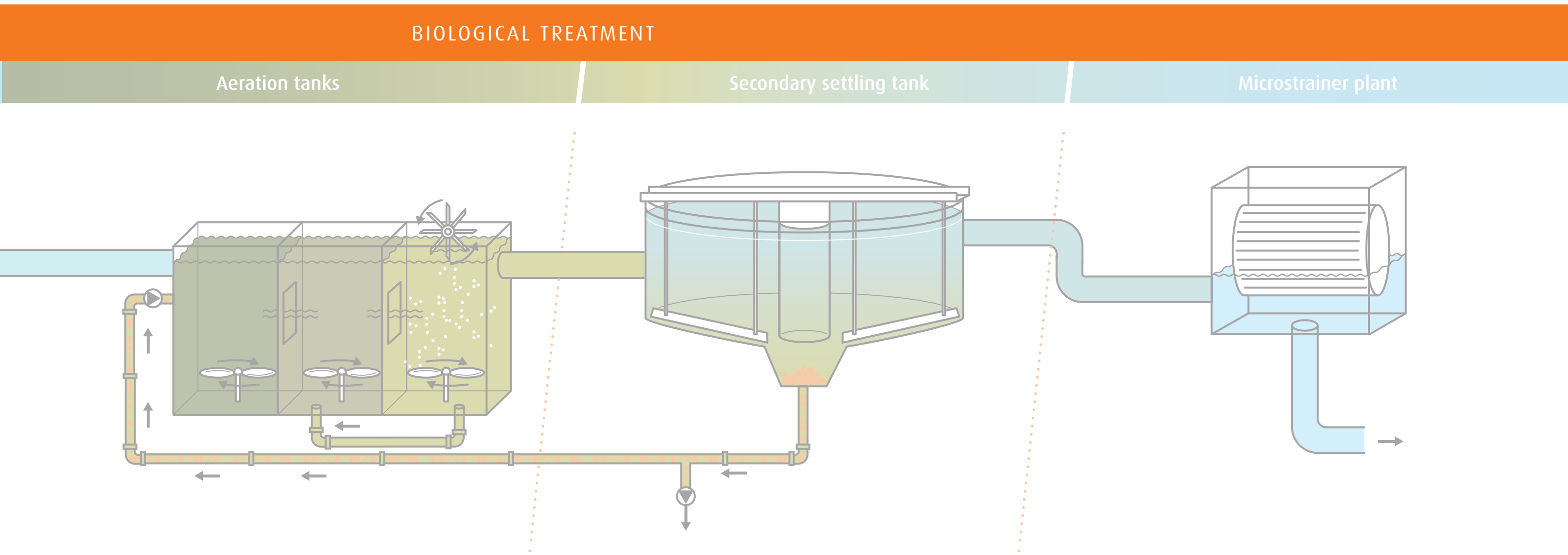
First, the incoming wastewater flows through the debris trap. Here, heavy coarse materials carried along, for example gravel or cobblestones, drop into a shaft and are removed regularly using a grab. In order that the debris trap does not clog up due to smaller particles or sludge, air is blown regularly from below, which keeps the lighter particles in the wastewater stream.

From the debris trap the wastewater flows into the screening chamber and there separates into three parallel lines. In each of these lines, two screens operate one after the other. First, a coarse screen with a gap width of 40 mm holds back larger solid bodies such as floating wood. An automatically controlled grab draws the retained screenings diagonally upwards. Subsequently, a fine screen with 6 mm gap width frees the wastewater of the smaller coarse substances such as paper and feces.

The screenings removed from the wastewater stream are comminuted, washed out using water, dewatered in a press, collected in a container and disposed of in a waste incinerator. The press water is fed to the primary settling stage.

IN DETAIL

- Number of screening lines: 3
- Gap width coarse screen: 40 mm
- Gap width fine screen: 6 mm
- Screenings per day: 1,400 kg



Directly at the inlet into the screening chamber there is a reception station for fecal matter where the contents of cesspits or transportable chemical toilets can be delivered.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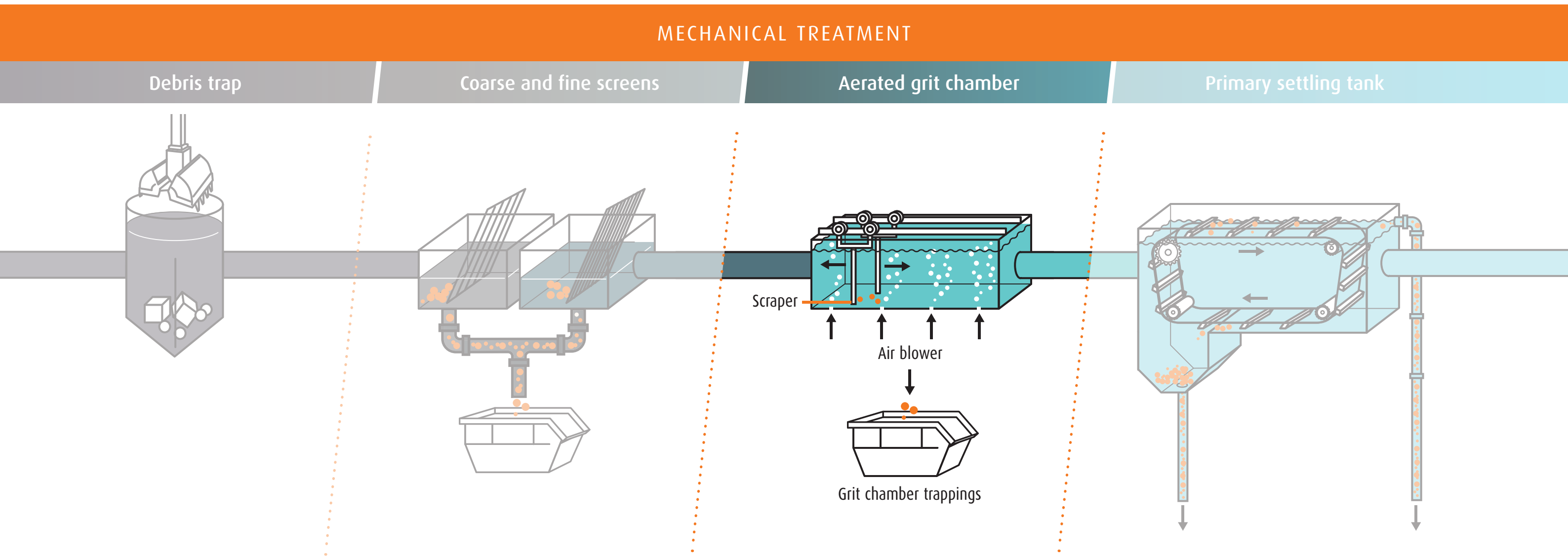
› The treatment plant operation requires a specialized technique and the inflow of wastewater has no pauses. Therefore, we take on the maintenance of our plant ourselves. Necessary spare parts are held ready in our own store. In their own workshops for mechanical and electrical engineering, our employees know their business sufficiently well and also ensure that operation in the case of an incident or damage functions correctly within the shortest time.

We carry out training!

In our plant the following trades can be acquired in interesting surroundings:

› Industrial mechanic (m/f)
› Electrical technician (m/f)
› Specialist for wastewater engineering (m/f)



» THE GRIT CHAMBER

No spanner (sand) in the works!

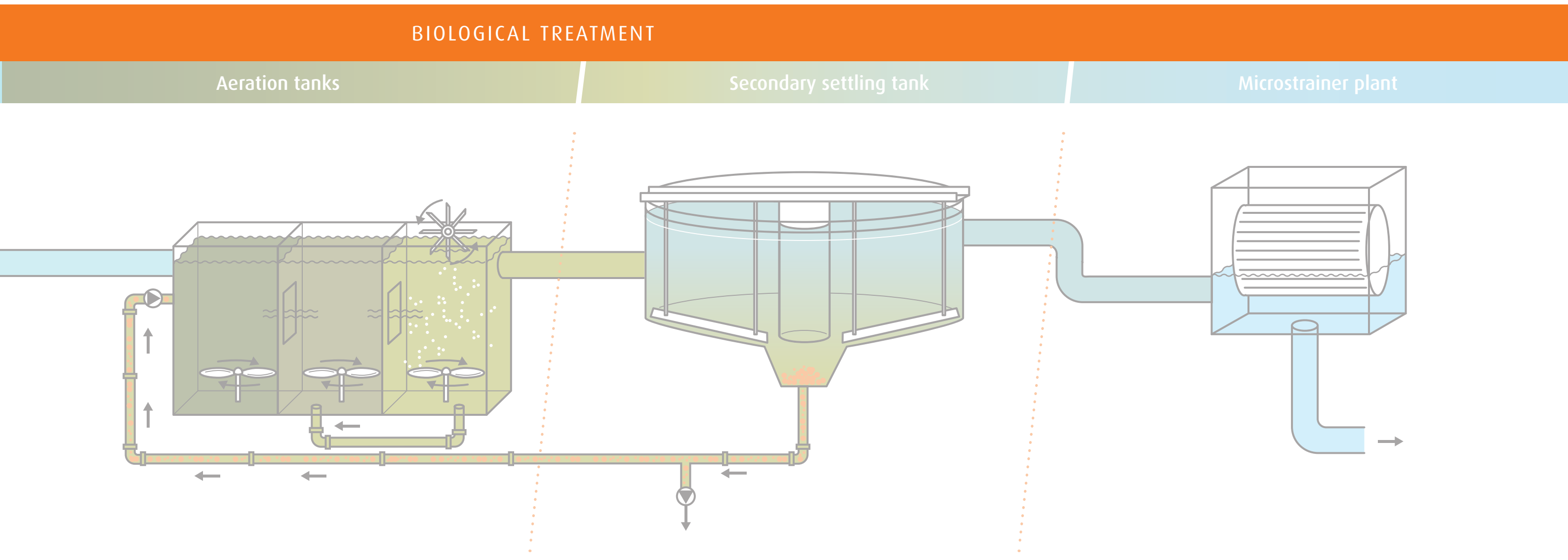
From the screening chamber the wastewater flows through two parallel longitudinal grit chambers, where the sand carried with it is settled. With this, it is ensured that no sand damages pipelines and pumps through its abrasive effect in the following treatment stages.

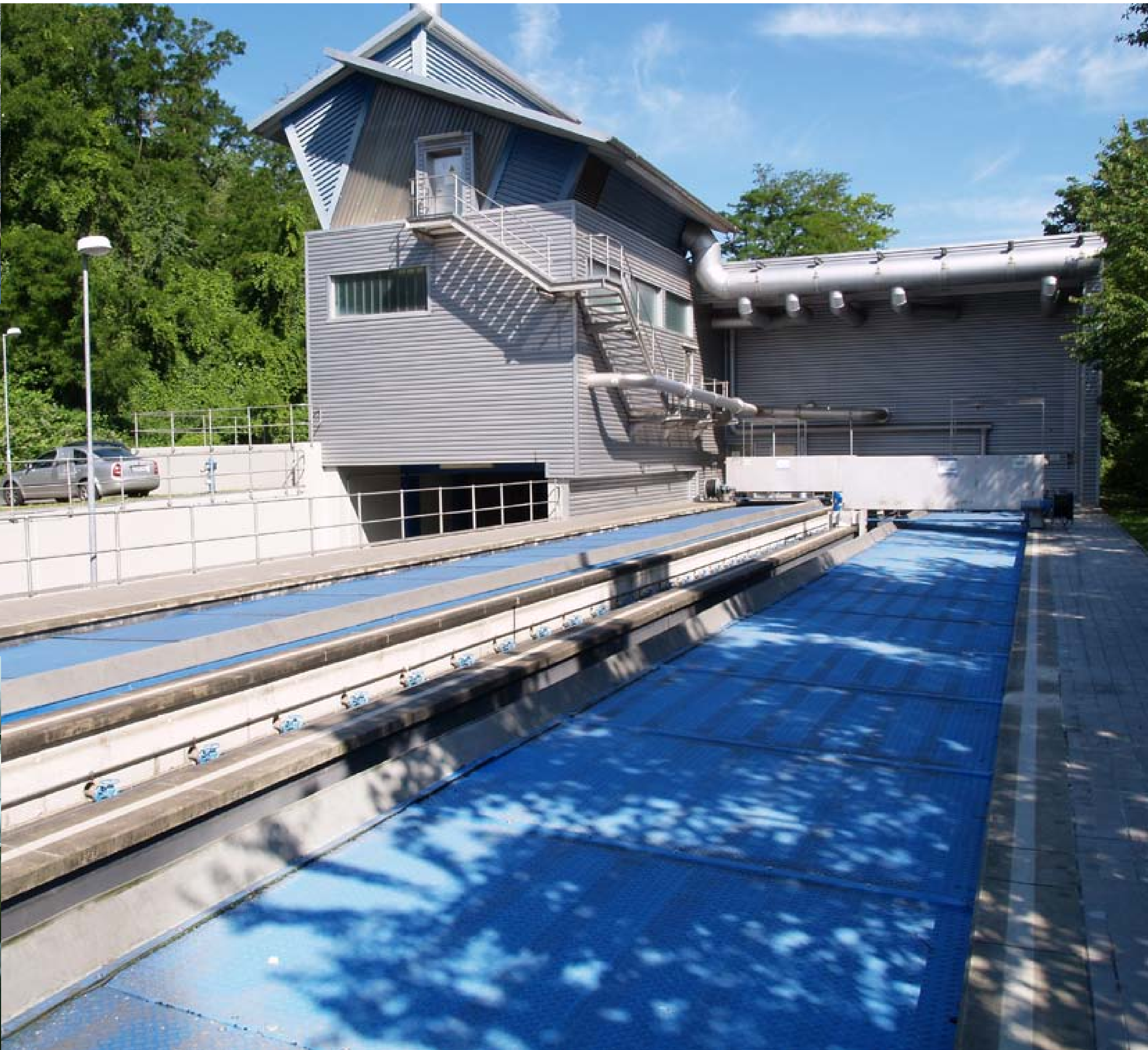
In order that the sand can settle, the wastewater flows very much slower than in the screening chamber so that the sand is no longer carried along by the flow. In addition, the grit chambers are aerated: air blown in from the side displaces the wastewater in a spiral movement. Through this, on one hand, the settling is encouraged, and on the other, fat and grease is separated. These float upwards and are removed at the end of the grit chambers.

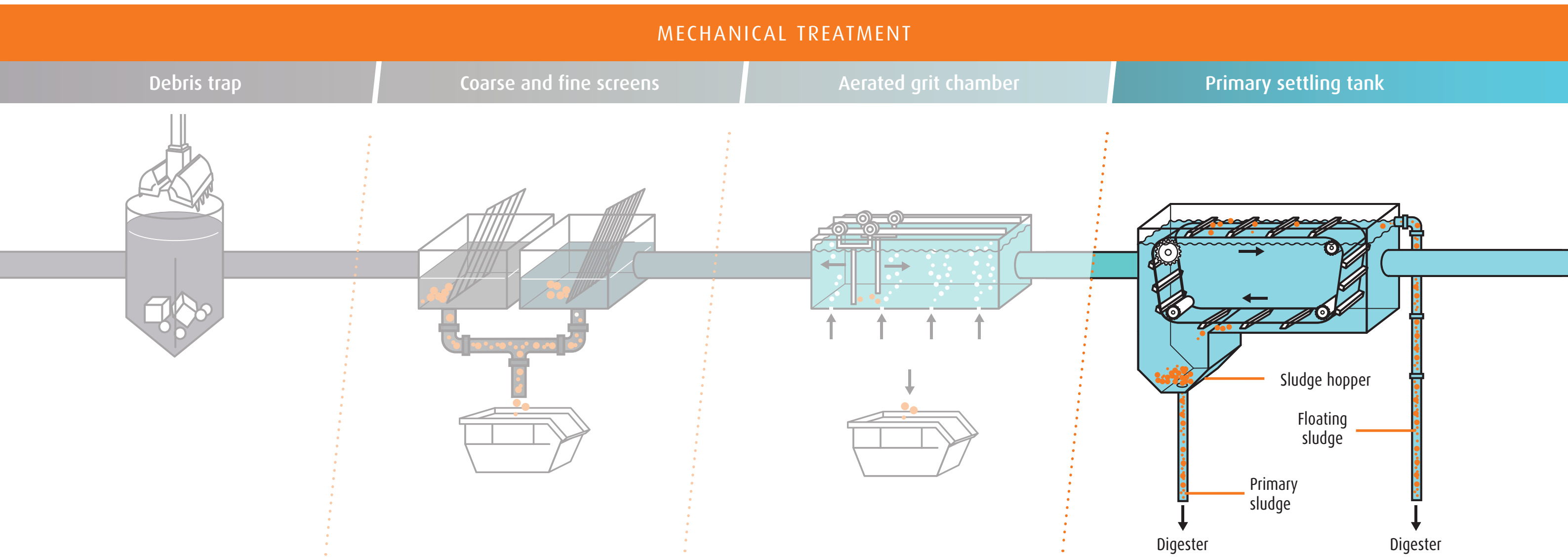
The settled sand is sucked away longitudinally by an automatically driven scraper, is collected in a container and disposed of. The fat and grease are pumped into the digesters for sludge treatment.

IN DETAIL

- Number of grit chambers: 2
- Flow rate: ca. 0.05 m/s
- Volume per grit chamber: 675 m^3
- Length of the grit chambers: 41 m
- Depth of the grit chambers: 5.3 m
- Grit chamber trappings per day: 800 kg
- Blower injected air volume: 7 m^3 per minute and grit chamber


BIOLOGICAL TREATMENT
Aeration tanks
Secondary settling tank
Microstrainer plant





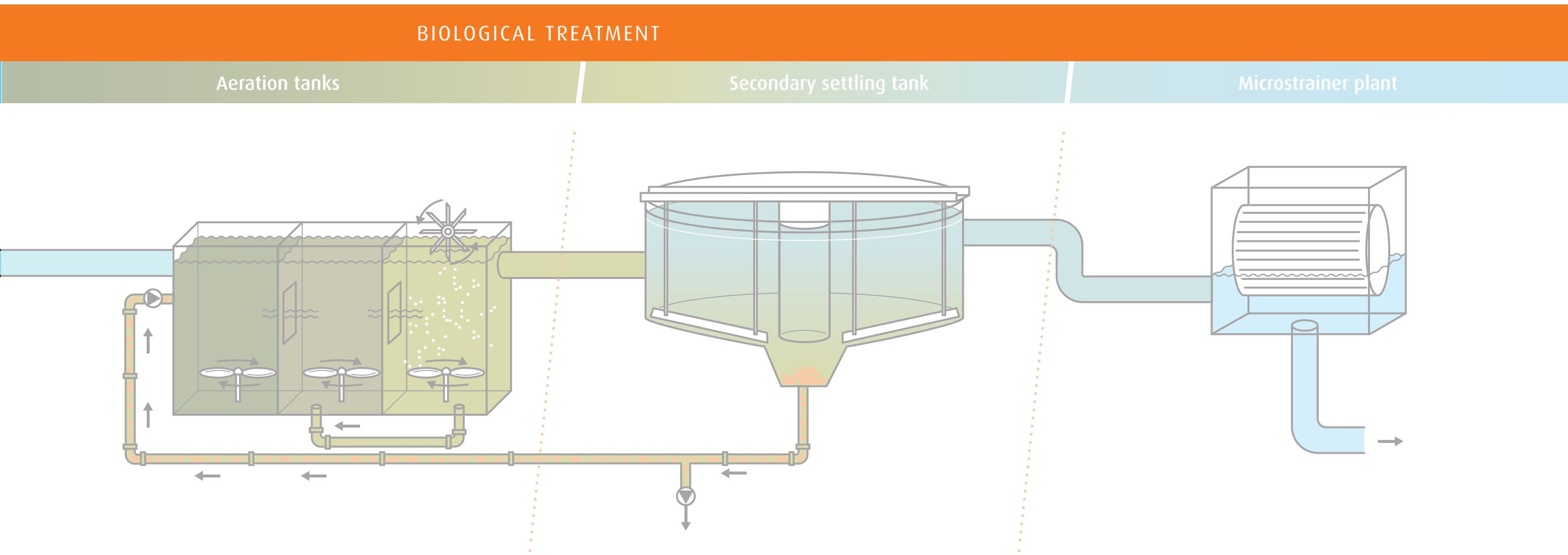
» PRIMARY SETTLING STAGE

Looks a lot better!

In the four primary settling tanks the undissolved solids are removed from the wastewater. For this, the flow rate of the wastewater is reduced even further. Even solids which up to now have remained suspended now sink to the bottom. The so-called primary sludge is pushed into a sludge removal hopper by a circulating chain scraper and is subsequently pumped into the digesters for sludge treatment.

Undissolved solids which are lighter than water rise as so-called floating sludge to the surface where they are pushed to the edge of the tank by the surface skimmers of the chain scraper. Here they are removed at regular intervals into a sludge channel and are also pumped into the digesters for sludge treatment.

With this, the mechanical part of the treatment procedure is concluded. Now, the wastewater – for the most part – freed of the undissolved pollutants and now already looks significantly cleaner than at the beginning.



IN DETAIL

- Number of primary settling tanks: 4
- Total volume: 2,600 m^3
- Length of primary settling tanks: 35 m
- Depth of primary settling tanks: 3 m (at hopper 5.4 m)
- Average sludge removal per day: 250 m^3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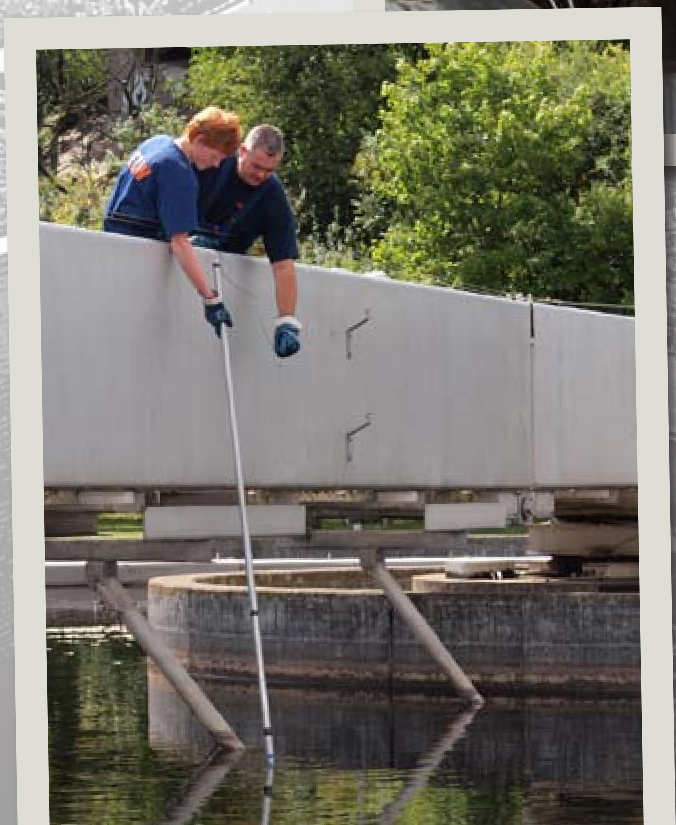


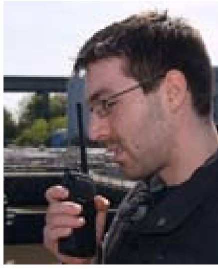
› **Approximately one third of our team works in rotating shift operation – the wastewater treatment works never sleeps! Although a lot of things run automatically, there is always something to be done. The shift teams are so composed that all qualifications are always available: wastewater engineering, electrical engineering, mechanical engineering.**

» THE MAIN CONTROL CENTER

Everything in view

High above the tank of the biological treatment stage, the main control center can be found. From here, the complete operation is controlled and monitored: around the clock, 7 days a week. All important operating data is displayed on large monitor screens: temperatures, flow rates, measured values, operating conditions. The overview provides us with an innovative process control system which, in addition, records and stores all data.

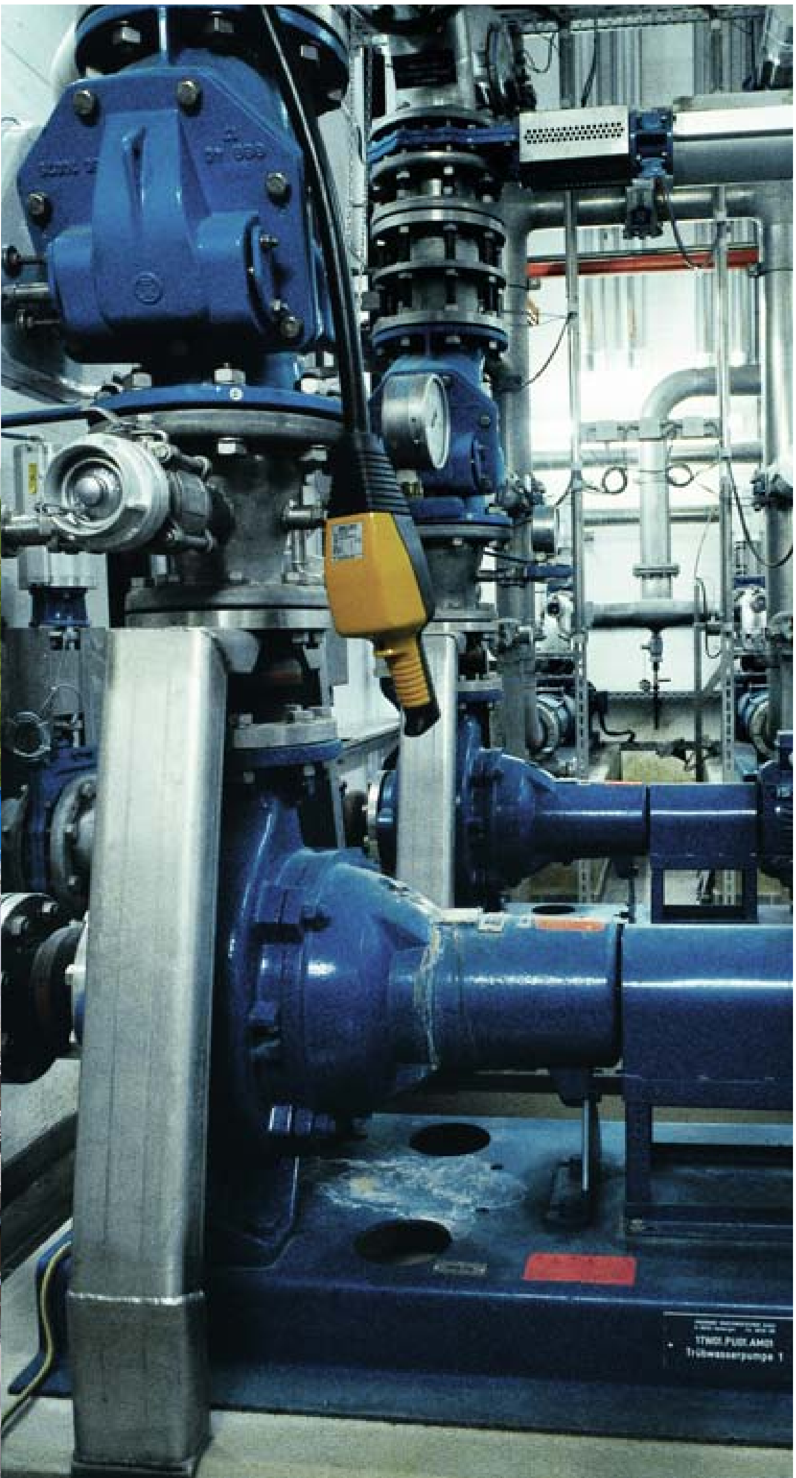
From the control center the shift leader is in radio contact with all members of staff on duty. Individual processes can be accessed immediately, directly and deliberately at any time. Not only the treatment plant itself can be monitored from the control center, but also the more than 800 km long Wiesbaden sewer system with external facilities as well as, by telecontrol engineering, the night operation of the Biebrich wastewater treatment plant. In case of any incident the standby service is notified immediately in order to correct the fault.



» MAN-ACCESSIBLE PIPE DUCT

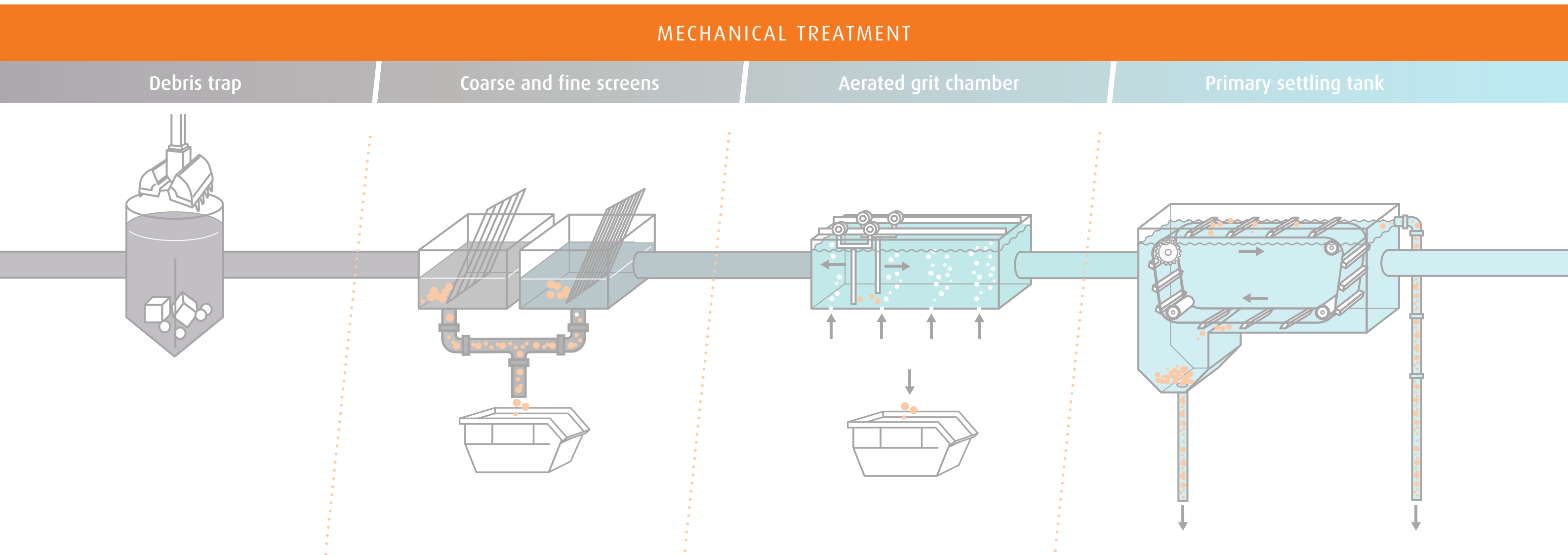
Invisible below ground

Below ground, our treatment plant, comprises of more than 250 technical units and many kilometres of pipe which ensure that wastewater, operating materials and sludge follow the planned paths.



In order to keep the engineering facilities accessible for maintenance and repair tasks they are located in man-accessible ducts. Here run operating and supply pipelines for potable water, sludge liquor and process water, the compressed air pipelines for the actuation of controlling equipment, natural gas and biogas as well as the cables for electrical measured data, control and energy supply. With this, the lines are so arranged in several levels that each line runs as straight as possible and pipelines and cables which cross each other are at different levels.

The in total 1.5 kilometers long ducts surround all settling tanks and are supplied with fresh air via a ventilation facility. For safety, smoke gas detectors, a gas measuring system and a person-locating system are installed.



» BIOLOGICAL TREATMENT

Millions of co-workers help

The mechanically treated wastewater contains almost only still dissolved pollutants: carbon and nitrogen compounds as well as phosphates. These substances are removed from the wastewater in the biological treatment. This is necessary because these, in nature, act as plant fertilizers and would lead to an over-fertilization of the rivers with very serious ecological consequences.

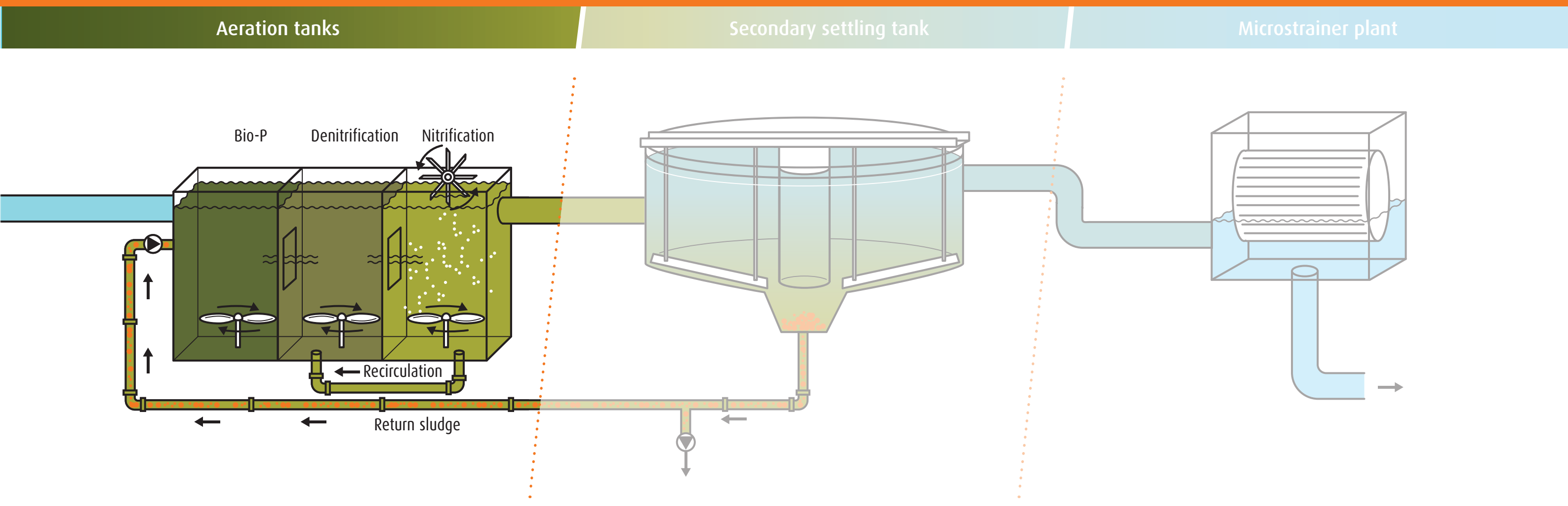
For the biological treatment, the wastewater is distributed to five lanes in which innumerable micro-organisms absorb and convert the dissolved substances. The micro-organisms overall form the so-called activated sludge which colour the wastewater dark brown.

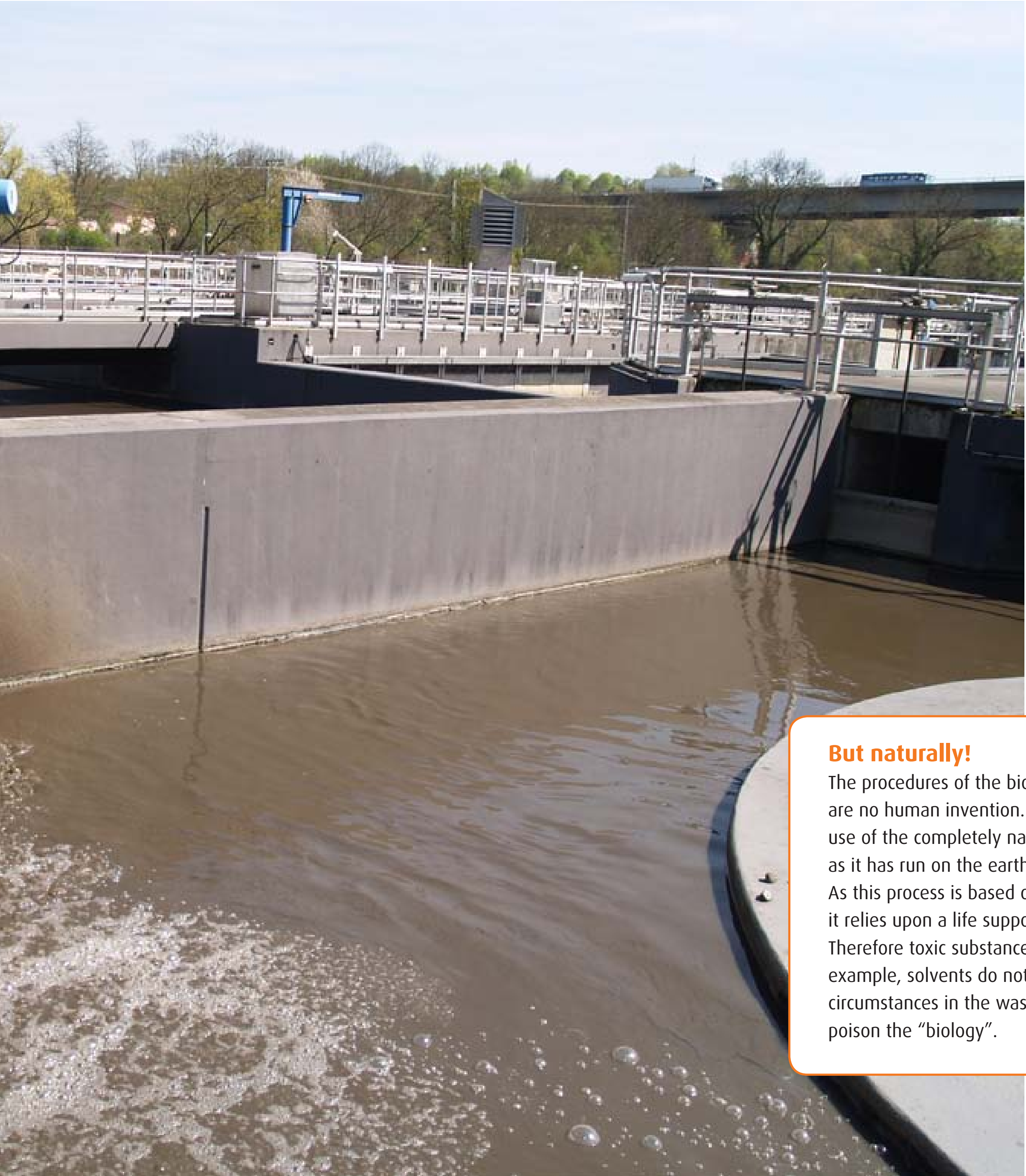
Due to the position between residential buildings and railway lines, special techniques were necessary in the Wiesbaden main wastewater treatment plant. In order to provide the required volume, the biological treatment is designed unusually deep which places special demands on the thorough mixing and aeration.

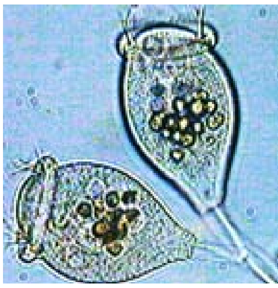
IN DETAIL

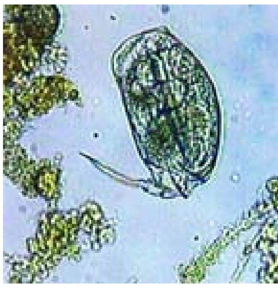
- Number of aeration lanes: 5
- Biomass concentration: ca. 3 kg/m³
- Volume per Bio-P tank: 1,870 m³
- Volume per denitrification tank: 2,390 m³
- Volume per nitrification tank: 8,380 m³
- Depth of the aeration tanks: down to 7.25 m

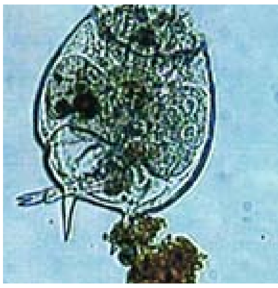
BIOLOGICAL TREATMENT





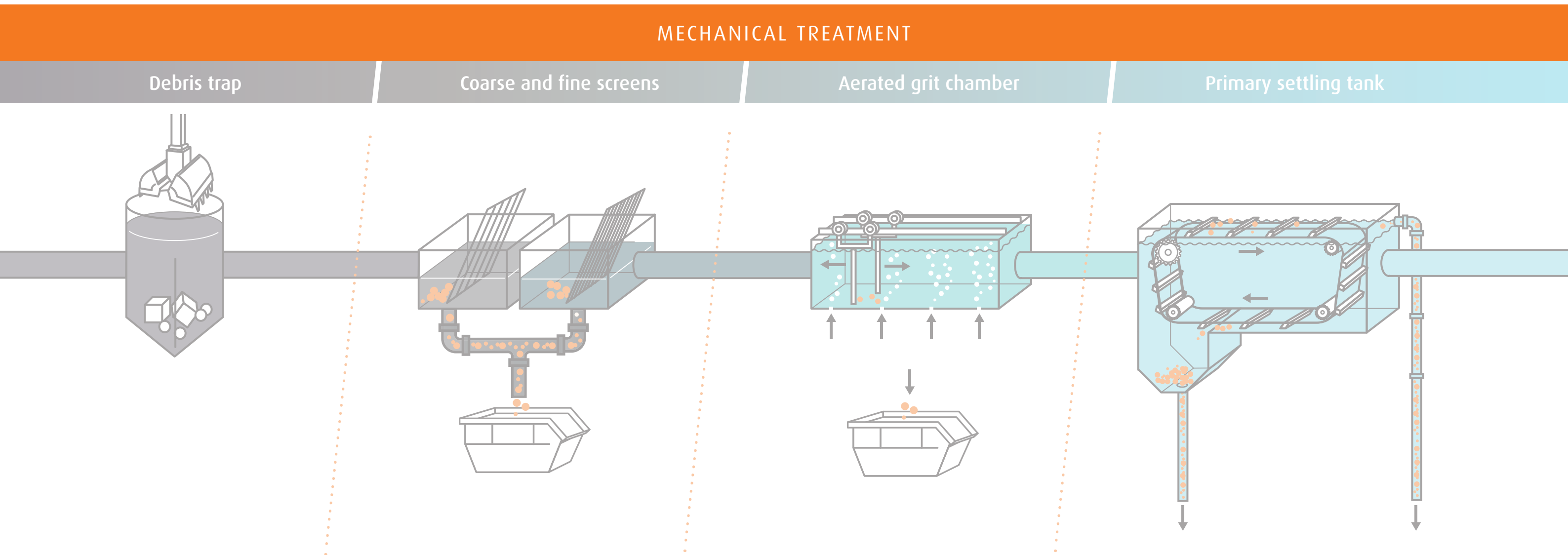






But naturally!

The procedures of the biological treatment are no human invention. With this, we make use of the completely natural nitrogen cycle as it has run on the earth for millions of years. As this process is based on living organisms, it relies upon a life supporting environment. Therefore toxic substances such as, for example, solvents do not belong under any circumstances in the wastewater. They would poison the “biology”.



Let us take a look at the procedures of the biological treatment without going too much into detail. It consists of 3 sections: biological phosphate removal (Bio-P), denitrification and nitrification. This sequence results from the metabolism of the micro-organisms.

In the **Bio-P tank,** the degradation of phosphate is introduced in an almost oxygen-free (as far as possible anaerobic) environment: as a result of the lack of oxygen, the bacteria become stressed and initially release phosphates which, in the later process, are taken out of the wastewater again to an excessive degree. The “completely stuffed” organisms are then discharged from the activated sludge system as excess sludge, whereby the phosphates, which have been taken up, move from the water path to the sludge path.

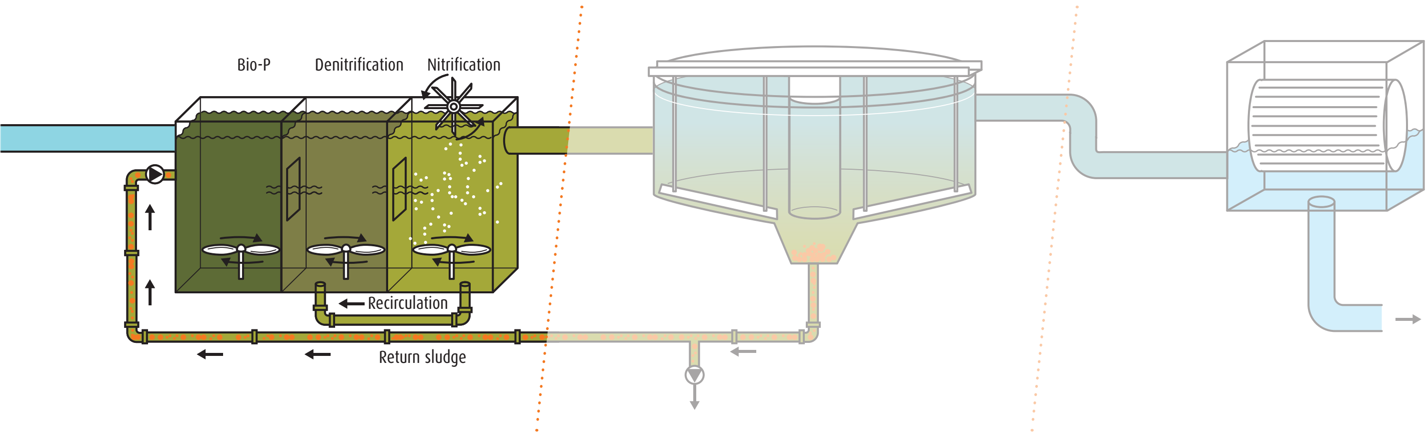
IN DETAIL

› **Explanation of terms:**

anaerobic: There is no oxygen present either in dissolved or in compound form.

anoxic: There is no dissolved oxygen present, however, oxygen in chemical compound form.

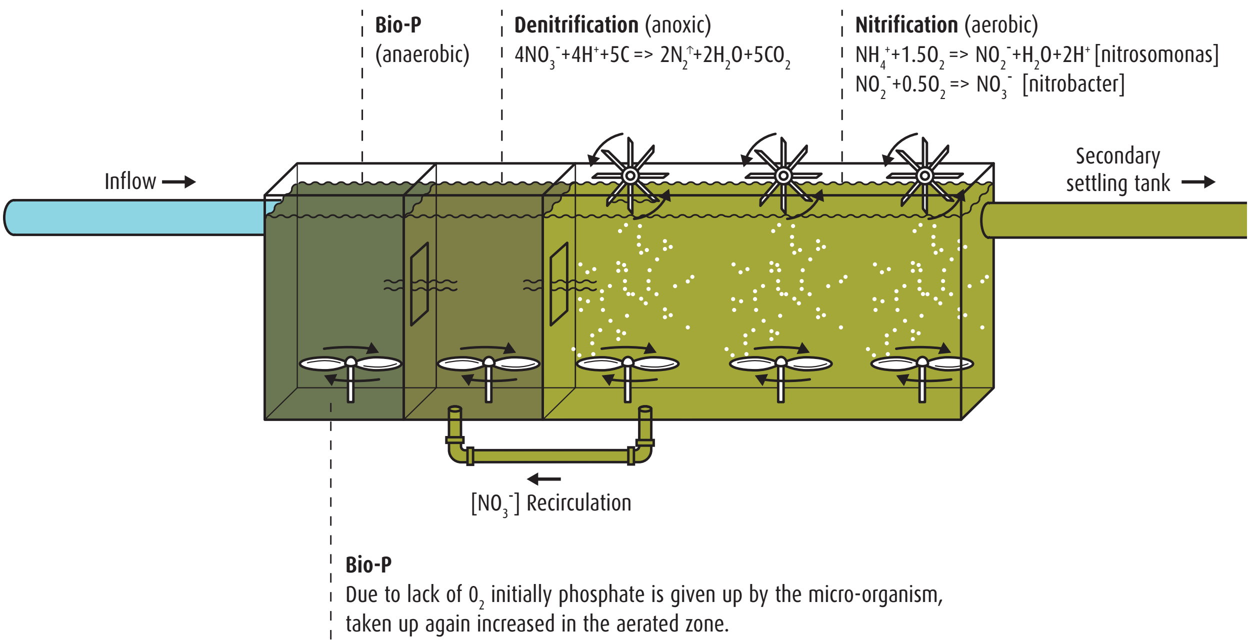
aerobic: Dissolved oxygen is abundantly available.



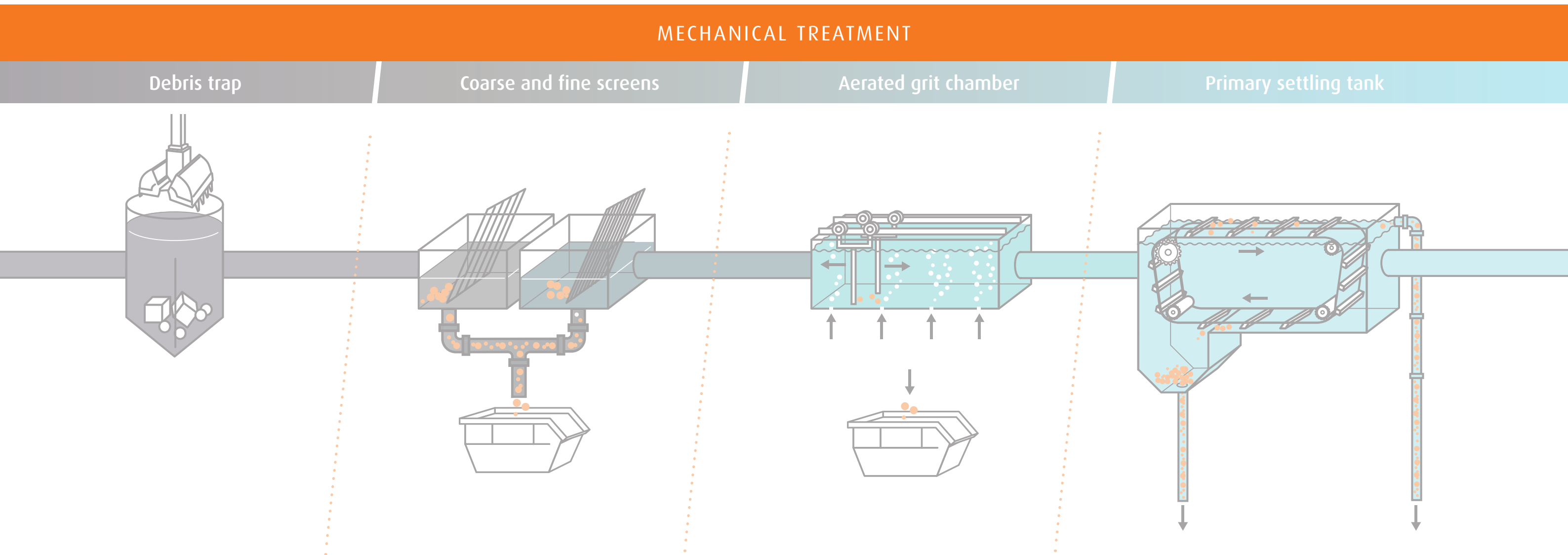
In **denitrification** there is an anoxic environment with only very little dissolved oxygen. This forces the micro-organisms to separate out the required oxygen for their metabolism from the nitrate (NO_3^-) formed in the wastewater. With this, the gaseous nitrogen is freed which escapes into the atmosphere; as our air is made up of 78 per cent nitrogen, it is completely harmless. As source of nitrate a precisely dosed amount of water-sludge mixture containing nitrate is pumped back (recirculation) from the subsequent nitrification.

Nitrification concludes the biological treatment. It takes up two thirds of the space and requires an as far as possible oxygen-rich (aerobic) environment. Therefore, so-called mammoth rotors inject ambient air via the surface of the water into the wastewater-sludge mixture. From ammonia nitrogen (NH_4^+) and the added oxygen nitrosomonas bacteria first create nitrite (NO_2^-). The nitrite is subsequently oxidized by nitrobacter bacteria into nitrate (NO_3^-). Parallel to this, other organisms extensively degrade the still present carbon compounds.

Biological treatment in summary



› **An efficient treatment operation is only possible if all conditions are right. For this, samples are taken daily at different positions and are analyzed in our works laboratory. Only this way we can ensure that the wastewater treatment plant operates optimally. In addition, online measuring stations are installed at all important points of the treatment plant. They transmit, inter alia, temperatures and pH values as well as oxygen, phosphate and nitrate concentrations to the control center in order that the operation can be controlled at the best. Specially qualified members of staff look after the maintenance.**



» SECONDARY SETTLING STAGE

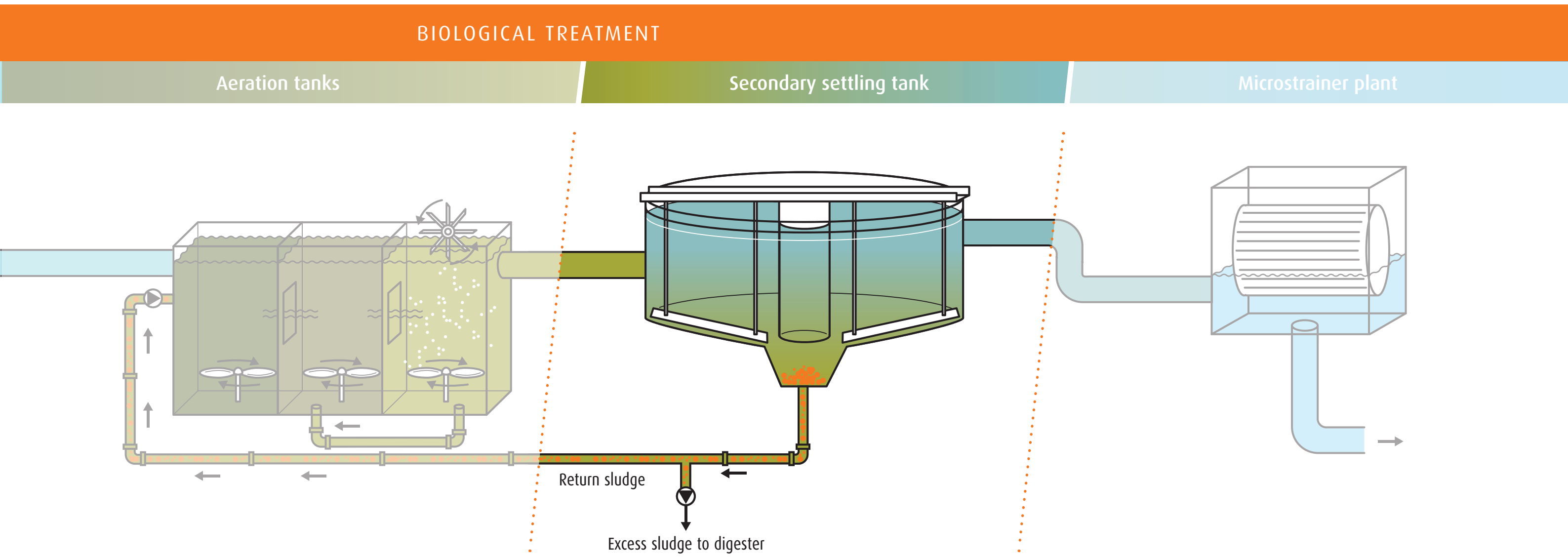
Just before the end

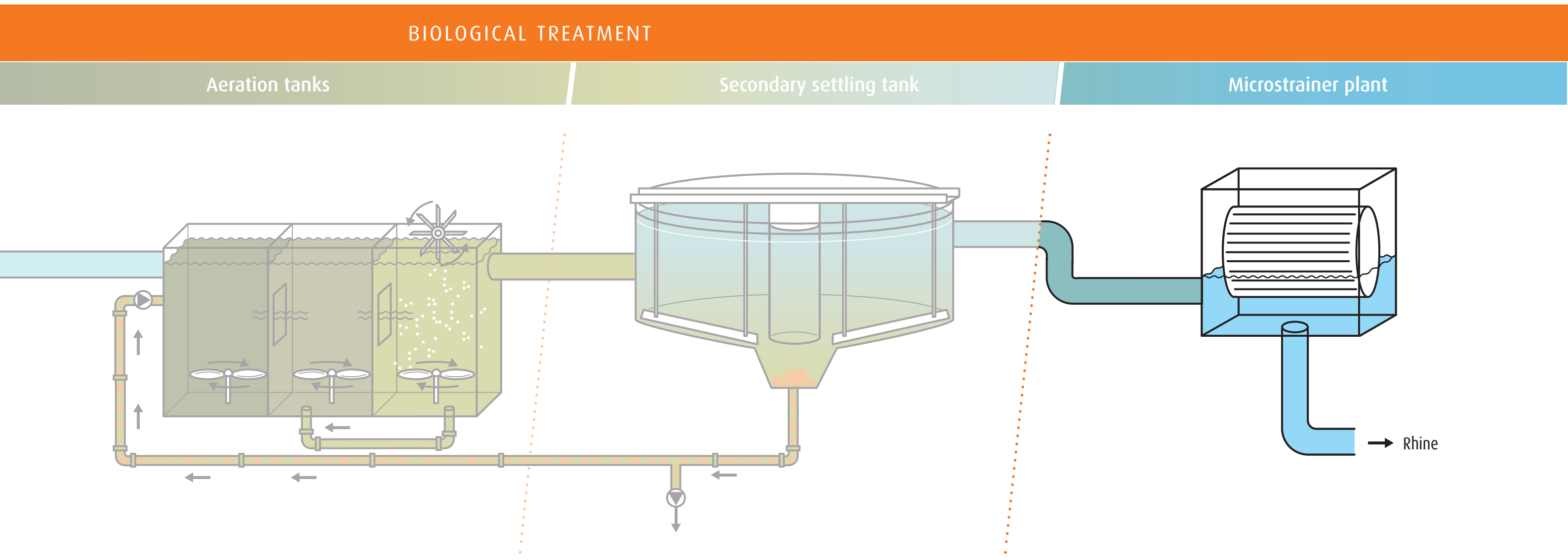
From the biological treatment comes a mixture of treated wastewater and activated sludge which, as a result of the sludge component, looks much dirtier than it really is. In order to separate wastewater and activated sludge from each other, the mixture is so calmed in six secondary settling tanks that the sludge, through its own weight, settles downwards and the rising treated wastewater flows into the surrounding collection channel.

The settled sludge is pushed into a collection hopper in the centre of the tank using the circulating scraper blades which are drawn over the tank bottom by the slowly rotating bridges. From there it is pumped as return sludge to the biological treatment tanks in order to maintain the biomass concentration there. As the organisms reproduce in the activated sludge, the complete quantity does not have to be returned. The quantity not required is diverted as excess sludge from the return sludge, is thickened and pumped into the digesters for sludge treatment.

IN DETAIL

- Number of secondary settling tanks: 6
- Total volume: 30,708 m³
- Tank diameter: 38 m


BIOLOGICAL TREATMENT
Aeration tanks
Secondary settling tank
Microstrainer plant
Return sludge
Excess sludge to digester



» MICROSTRAINER PLANT

Everything must go

The wastewater flowing out of the secondary settling tank still contains very fine suspended solids. These particles are taken over a microstrainer before the wastewater is discharged into the Rhine.

The wastewater from the secondary settling stage is distributed to five, large slowly rotating strainer drums each made up of 144 fine strainer baskets. It flows through the strainer from inside outwards. The pollutants settled on the inside are flushed into a hopper by a sprayed water plant during rotation. The strainers have to be cleaned chemically only for lime deposits. The strainer sets are replaced in rotation every five years.

The quality of the treated wastewater which leaves the microstrainer is permanently monitored using an online measuring station. Result: the legal specified values are well undercut. Our Wiesbaden main wastewater treatment plant thus makes an important contribution to the water quality of the Rhine – and to the quality of life for everybody.

IN DETAIL

- Strainer drums: 5
- Drum size: 9.5 m long, 4 m in diameter
- Strainer basket per drum: 144 (24 x 6)
- Strainer mesh width: 20 µm (0.02 mm)
- Water throughflow per drum: 1,800 m^3/h

» WORKS LABORATORY

Sampling

Colleagues in the works laboratory have plenty of variety: the wastewater and sludge samples taken daily have to be analysed and evaluated. From this result important findings on the status of the process procedures – for example whether there is enough activated sludge in the biological treatment stage, or whether the content of organic acids in the digester indicates stable operation. The control center is informed immediately of any abnormalities.

The works laboratory is not only for the treatment works itself but is also available to other areas. For example, here we also investigate well and percolation samples from the landfills or air samples from the city area.

» PLANNING AND CONSTRUCTION

At the state of the art

In order to maintain the value and the functional efficiency of both the Wiesbaden wastewater treatment plants, construction measures are unavoidable. Thus, concrete structures such as treatment tanks and digesters are emptied regularly in order to examine the basic structure for damage and, as required, carry out rehabilitation. Digesters are cleaned approximately every fifteen years, reviewed and, if necessary, repaired. But legal requirements can also demand conversion and expansion measures, for example in order to optimize the exhaust air emissions or for the removal of trace elements and disinfection of the wastewater.

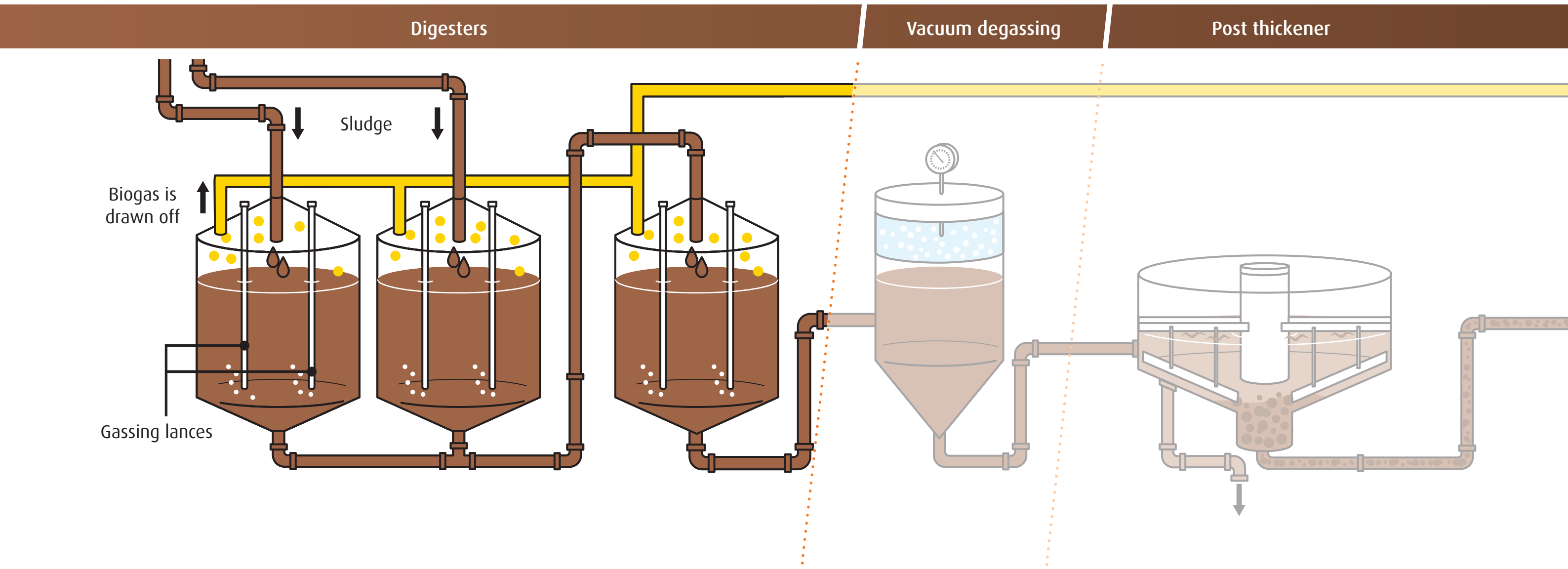
In order that these construction measures do not impair the running operation, they have to be well-organized. Therefore, they are planned by us in-house and are carried out under our direction. Even the complete conversion of the main wastewater treatment plant (1993 to 2003) and the new construction of the sludge treatment in the Biebrich treatment plant (2004 to 2010) were realized by the planning and construction department.

The path of the sludge

With the treatment of the wastewater, some 600 m^3 of sludge is produced daily of which ca. 250 m^3 as primary sludge from the primary settling stage and 350 m^3 as excess sludge from the secondary settling stage.

The sludge is also treated using the example of nature: controlled digestion procedures release energy and close the material cycle.

At the end, the remaining sludge is dewatered and fed to incineration.



» DIGESTERS

Energy from sludge

The most important step in sludge treatment is digestion. It takes place in the three distinctive digesters, the eye-catcher of our treatment plant.

In order to degrade the organic matter contained in the sludge optimally, a heating up to 35–37°C is necessary. At these temperatures various strains of bacteria produce so-called biogas, which consists mainly of highly inflammable methane, from the organic matter. Therefore, a digester may be accessed only under strict safety precautions.

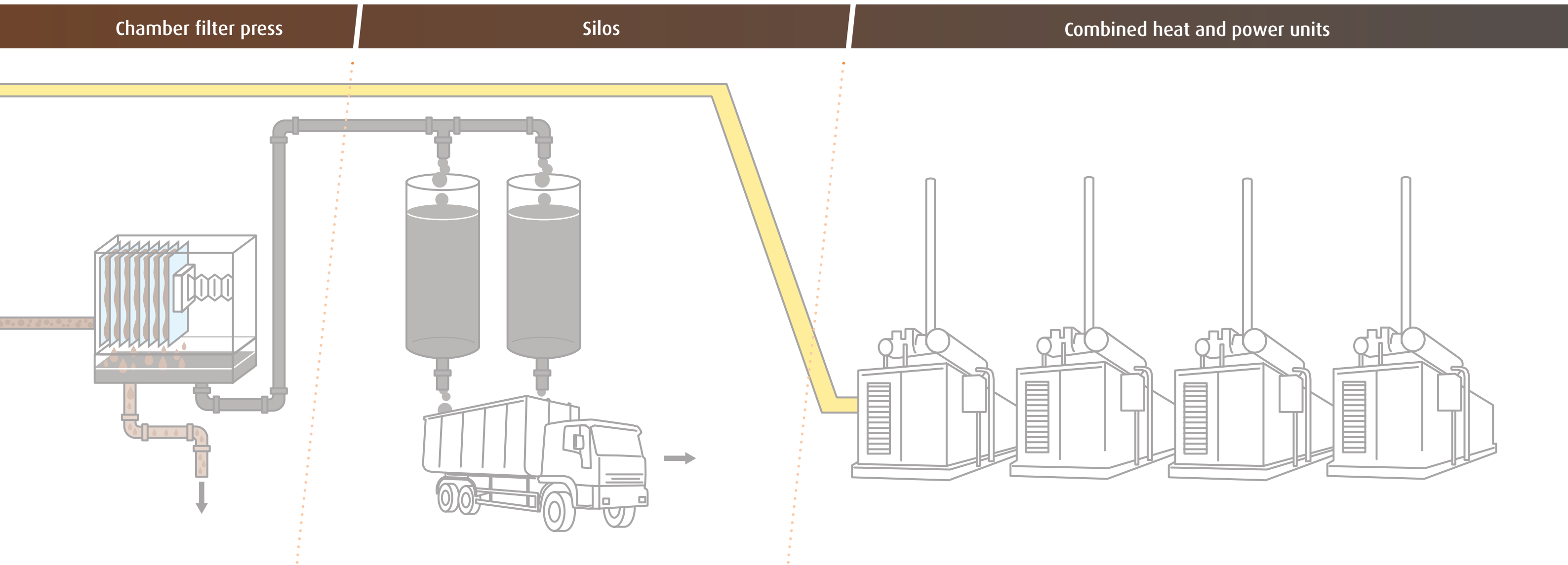
The digestion process reacts very sensitively to light, oxygen and abrupt changes of temperature. In order to check, in the truest sense of the word, whether the chemistry is right, sludge samples are taken daily. In addition, the contents of the over 17 m high digesters must always be well mixed. Biogas is blown in at the bottom via so-called gassing lances and circulates the sludge.

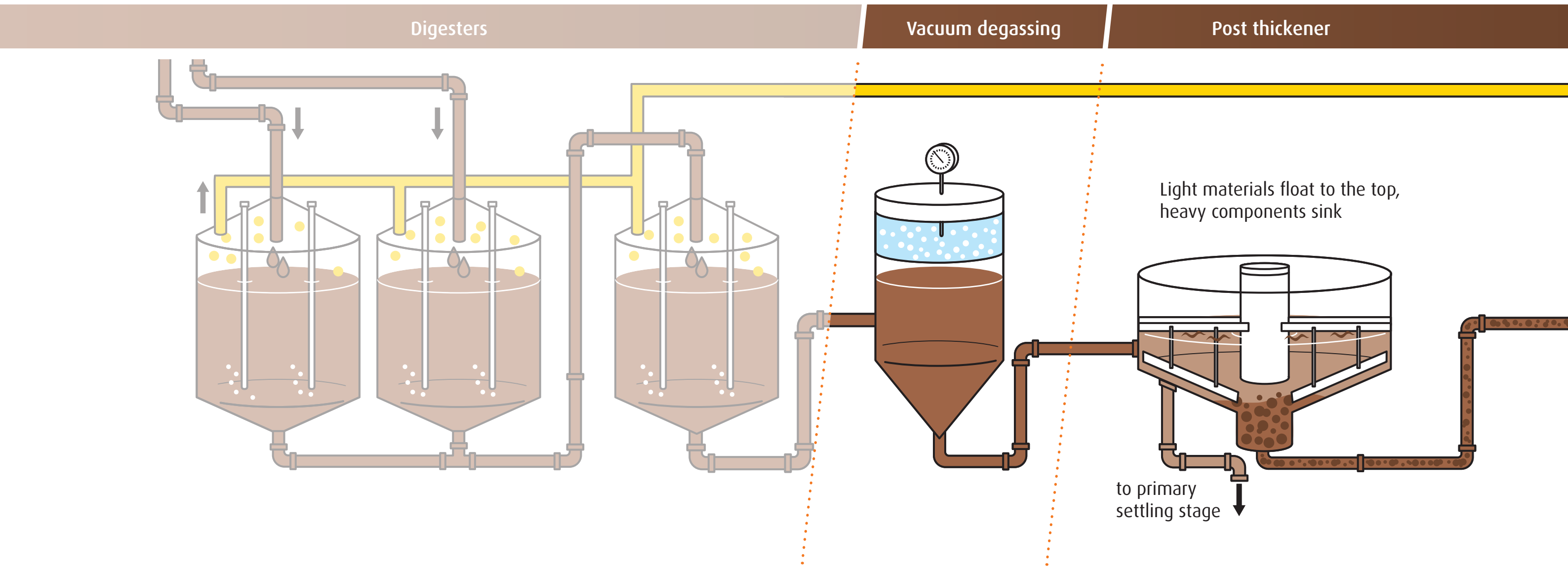
Following a retention time of ca. three weeks, only compounds which are very difficult to degrade remain in the digesting sludge; the biogas production reduces. Then we designate the sludge as “completely digested” and remove it from the digester.

The digestion process, on one hand, reduces the sludge volume and, on the other hand, energetic biogas results with which the combined heat and power plant is driven for the production of electrical power and heat.

IN DETAIL

- Number of digesters: 3
- Volume per digester: 4,500 m³
- Digestion temperature: 35-37 °C
- Duration of digestion: ca. 3 weeks
- Biogas production: ca. 2,850,000 m³ per year


Chamber filter press
Silos
Combined heat and power units

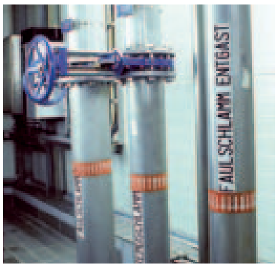


» SEWAGE SLUDGE DEWATERING

Well pressed!

The digested sludge is thickened in order to reduce the sludge volume and to save disposal costs.

First, the sludge passes through a hopper-shaped container in which a vacuum exists. Through this, the remaining biogas bubbles free themselves from the sludge, which improves the following thickening process. Subsequently the sludge, due to gravity, settles on the floor in the two post thickeners, whereby a further separation of water and sludge takes place. The conclusion of the dewatering is formed by the two filter presses which accept the sludge from the post thickeners. The remaining water is pressed out with 15 bar pressure.

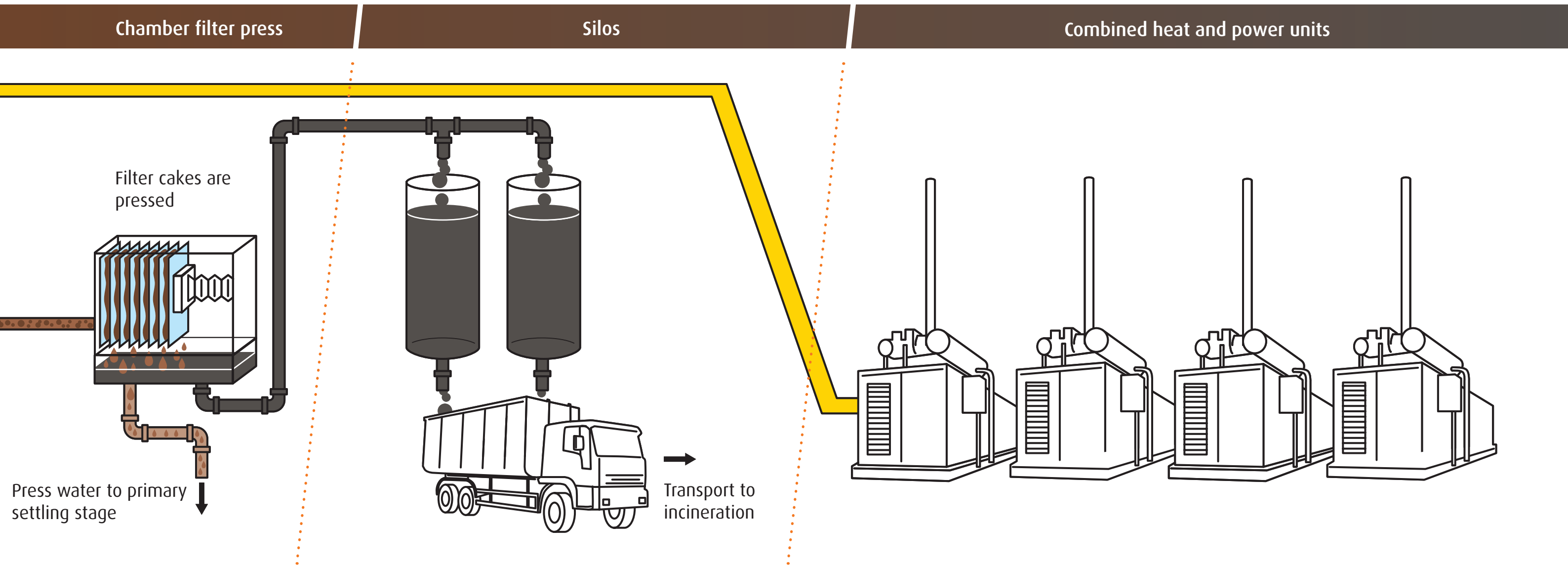


IN DETAIL

- Number of post thickeners: 2
- Volume per post thickener: 700 m³
- Number of filter presses: 2
- Number of filter chambers per press: 82
- Volume per charge: ca. 60 m³
- Press pressure: 15 bar

This takes ca. two hours and reduces the sludge volume to a sixth. Organic flocculation agents assist the dewatering process. The “filter cake”, created in the filter press, has a dark brown colour and feels like damp garden earth. It is transferred into two silos using thick sludge pumps. Heavy goods vehicles (HGVs), loaded from these silos, take the sludge to external incineration.

The complete process water, which is produced by the sludge treatment, is pumped to the primary settling stage and thus again into the biological treatment process.



» COMBINED HEAT AND POWER PLANT

Self-provider

The resultant biogas is used on the spot as energy source. For this, we operate a plant of four combined heat and power units which produce both electrical power and heat from the gas (power-heat coupling). The heat energy is fed into the operations own long distance energy network via a hydraulic switching system.

The power plant covers our heat requirement completely and our regular electricity requirement to 60 to 65 percent. The remaining electrical power is drawn from the energy supply network. If this network fails, the power plant can maintain the emergency power operation.

IN DETAIL

- Nominal electricity output per power plant unit: 630 kW
- Nominal thermal output per power plant unit: 800 kW
- Model: MWM TBG 616 V16K
- Year of construction: 1998

Our primary objective is to cover completely the electricity requirement of the treatment plant via combined heat and power units. In other words: the energy for wastewater treatment is already brought by the wastewater – that is renewable energy of the very best kind. In addition, we are always trying to lower the energy consumption through optimization processes.

› **At the end of the treatment process, not only clean water flows into the Rhine, but we have also optimally utilized the pollutants in the form of sludge and gained back a large amount of energy out of this. We commit ourselves every day for this, therefore we are happy to work in one of the most modern wastewater treatment plants in Germany.**

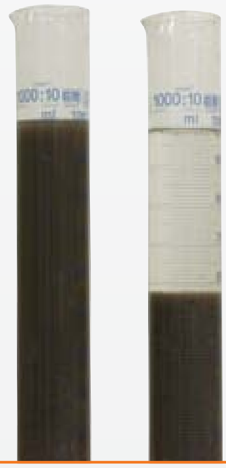
WATERPATH

Discharge from the grit chamber into the primary settling

The wastewater still contains floating greases and numerous undissolved substances.

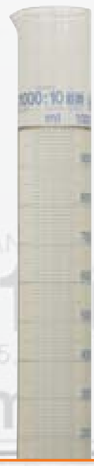
Discharge from primary settling into biological treatment

The dissolved pollutants still cloud the wastewater, but undissolved and floating matter are removed.



Water sample nitrification

Already after a few minutes, the activated sludge settles – the secondary settling is based on this. The wastewater itself contains practically no visible pollution.



Discharge microstraining

This water is discharged into the Rhine.

SLUDGEPATH

Sludge removal from the post thickeners

The water component is still so high that the sludge behaves fluidly.

Filter cake from the filter press

The sludge is transported to incineration in this condition.

Technical data

(based on the 2009 values)

Capacity, Design	PT	325,000		
Natural inhabitants	I	190,000		
Capacity, Average	PT	250,000		
Dry weather inflow	m^3/h	2,700		
Wet weather inflow	m^3/h	7,200		
Average wastewater inflow	m^3/d	50,000		
Energy				
Electricity requirement	kWh/a	10,987,616		
Of which own generation	kWh/a	6,522,056		
Biogas production 2009	m^3/a	2,838,881		
Analysis values according to DIN				
Parameter (mean)		Inflow ø	Declared limiting value	Discharge ø
TKN	mg/l	48		3
$N_{tot, inorg.}$	mg/l	30	8	6
Of which NO_3-N	mg/l	0		5
Of which NO_2-N	mg/l	0		0.1
Of which NH_4-N	mg/l	30		1
P_{tot}	mg/l	8	1	0.2
COD	mg/l	665	40	25
BOD_5	mg/l	371	15	3
Annual loads into the Rhine				
BOD_5	kg/a	60,346		
COD	kg/a	486,478		
$N_{tot, inorg.}$	kg/a	107,998[1)]		
P_{tot}	kg/a	3,515[1)]		
Residues				
Screenings	to/a	520		
Grit chamber trappings	to/a	290		
Sewage sludge (dewatered)	to/a	25,000		

[1)] The determined annual loads for N_{tot} and P_{tot} are based on online measurements and deviate from the analysis values due to the essentially high measurement density

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