Viikinmäki
wastewater treatment plant
Based on the load, the Viikinmäki wastewater treatment plant in Helsinki is the largest in Nordic countries. The wastewater treatment plant processes wastewater from industry and 800,000 people in Helsinki and its seven neighbouring municipalities. The average wastewater flow is 280,000 m³/day and the peak flow is 700,000 m³/day. Of the total flow into the plant, approximately 85% is domestic wastewater and 15% is industrial wastewater.

In the treatment process at the activated sludge plant operating with the simultaneous precipitation method, the wastewater is treated mechanically, chemically and biologically. The treated wastewater is fed through a 16-kilometre discharge tunnel into the sea sufficiently far from the coastline. The sludge separated from the wastewater is digested, and the biogas generated in the digestion process is used to produce heat and electricity for the wastewater treatment plant. The dried and digested sludge is processed into garden soil in the composting field. The designed capacity of the biochemical section of the Viikinmäki wastewater treatment plant is 310,000 m³/day. The design value for the $\text{BOD}_{7\text{ATU}}$ load is 69,000 kg/day, 2,100 kg/day for the phosphorus load and 15,500 kg/day for the nitrogen load. When calculating 70 g $\text{BOD}_{7\text{ATU}}$/inhabitant, the resulting population equivalent is 840,000.

After the wastewater treatment plant was commissioned in 1994, the process has been made more efficient and the capacity of the plant has been increased several times. At the start of 1998, denitrification was made more efficient by changing over to the DN process. The effectiveness of denitrification was increased further when the after-filtration unit was introduced at the end of 2003. At the start of 2004, the eighth activated sludge line was started in order to increase capacity. The maximum capacity of the plant was reached in 2014 when the 9th biological treatment line was introduced.

Solar panels were installed on the roofs of Viikinmäki wastewater treatment plant in summer 2016.

100 years of wastewater treatment

The first wastewater treatment plants in Helsinki were built in the 1910s to save the Töölönlahden Bay. At first, wastewater was treated with crushed stone filters and septic tanks but, as early as the 1930s, the first active sludge plants in the Nordic countries were commissioned in Helsinki. Before the Viikinmäki wastewater treatment plant was commissioned in 1994, a total of 12 wastewater treatment plants had operated in the Helsinki area.
Incoming wastewater

- $Q_{cm}$: 280,000 m³/day
- BOD$_{cm}$: 250 mg/l
- SS: 290 mg/l
- N-tot: 50 mg/l
- P-tot: 6.6 mg/l
- COD$_{cm}$: 550 mg/l

**Pre-treatment**
- Screening: Sand removal
  - 4 screens, screen size: 10 mm
  - 4 tanks, total tank volume: 2,144 m³, retention time: 13 min.
- Preliminary aeration: Tank volume: 8,800 m³ in total, retention time: 52 min.

**Preliminary settling**
- 7 lines, 14 tanks
  - Total tank volume: 34,850 m³
  - Retention time: 3.5 hours
  - Surface load: 1.4 m³/h

**Aeration**
- DN Denitrification-Nitrification process: 9 tanks, with 6 sections each
  - Total tank volume: 103,500 m³
  - Retention time: 8.0 h

**Secondary settling**
- 9 lines, 18 tanks
  - Total tank volume: 118,260 m³
  - Retention time: 9.0 h
  - Area: 18,450 m²
  - Surface load: 0.7 m³/h

**Biological filter**
- Denitrification filter (Biostyr)
  - Retention time: 25 min.
  - 10 filter units
  - Methanol consumption 8,000 kg/day

**Chemicals used**
- Ferrous sulphate: 9,000–10,000 t/year
- Lime: 2,900–3,200 t/year
- Methanol: 0–2,500 t/year
- Polymer: 90–100 t/year

**Pre-treatment**
- Sand removal: 4 tanks, total tank volume: 2,144 m³, retention time: 13 min.
- Preliminary aeration: Tank volume: 8,800 m³ in total, retention time: 52 min.

**Screening**
- 4 screens, screen size: 10 mm

**Digestion**
- Total tank volume: 10,000 m³ in total
- To be digested: 2,400–2,900 m³/day
- Solids content: 3.4%

**Drying sludge**
- Dried sludge: 65,000 t/year
- Solids content: 29%

**Composting**
- Composted: 100,000 m³/year
- Reprocessed to soil products: 80,000 m³/year

**Biogas**
- Produced: 13.4 million m³/year

**Metsäpirtti soil**
- Digested and dried sludge is transported from Viikinmäki to the Metsäpirtti composting field in Sipoo. The sludge is mixed with peat in a ratio of 1:1. The mixture is composted in stacks for approximately six months, after which sand and biotite are added to it. During the last processing phase, the soil mixture is screened (screen size: 20 mm). In the Metsäpirtti soil products, approximately 580 tonnes of phosphorus and 620 tonnes of nitrogen are recycled annually. The quality of the soil products is monitored by EVIRA.
Treatment process & treatment requirements

All the wastewater treatment processing facilities have been excavated into rock. The treatment is done with the traditional activated sludge method, where the removal of phosphorus is carried out at the same time in two-phase simultaneous precipitation. Ferrous sulphate (FeSO₄) is used for precipitating the phosphorus, and the resulting phosphorous sediment is bound to the sludge. If necessary, the alkalinity of the water is increased using hydrated lime (Ca(OH)₂). The bypass water is treated in a separate treatment process.

The first phase of nitrogen removal is done during the activated sludge process with the preliminary denitrification principle, and the second phase occurs in the biological denitrification filters. In the aerated sections of the activated sludge process, the ammonium nitrogen contained in the wastewater is oxidised into nitrate nitrogen (NO₃⁻), which is reduced into nitrogen gas (N₂) in the un-aerated sections of the process. The activity that occurs in the oxygen-free conditions of both the DN process in the activated sludge tank and the Biostyr® filter is based on the ability of denitrification bacteria to reduce nitrogen in nitrate form into free nitrogen gas, releasing the nitrogen in the wastewater into the atmosphere. No chemicals or external biomass are added to the activated sludge process, but in the after-filtration phase, denitrification is accelerated by introducing methanol (CH₃OH). The temperature of denitrification processes varies between 9–18 °C.

The sludge generated in the treatment process is processed in digestion tanks. The methane gas generated in the digestion process is utilized in energy generation to produce electricity and heat. The energy generated corresponds to 70% of the wastewater treatment plant’s electricity needs. In 2017, the aim is to achieve 80% self-sufficiency. The wastewater treatment plant is self-sufficient regarding heat. The digested sludge is dried using a centrifuge; the process is accelerated with polymer. The dried sludge is taken away for further processing into soil products at the Metsäpirtti composting field in Sipoo.

Continuous research and development work is done at the Viikinmäki wastewater treatment plant with the goal of ensuring high-quality wastewater treatment both now and in the future. The growing population in the Helsinki Metropolitan Area and the changes caused by global warming present new challenges to the wastewater treatment plant, as the amount of wastewater and extreme climate phenomena increase; in addition, the wastewater treatment plant’s current capacity is insufficient to achieve the results required by the increasingly strict treatment requirements. In addition to developing the process, increasing the plant’s energy-efficiency is also an important development target.

The 9th treatment line was introduced in 2014 in connection with the expansion in 2004, an area reserved for the 9th biological treatment line was excavated in the wastewater treatment plant cave; the line’s construction and mechanisation work began at the start of 2013. The factor that started the project involved the treatment requirements set for the plant, which are becoming increasingly difficult to fulfil as the nutrient load in the incoming wastewater continues to grow and the fluctuations in flow are increasing and becoming stronger. The line was introduced in 2014, and increased the biological treatment capacity by approximately 12%.

Technical specifications*

### Incoming wastewater

<table>
<thead>
<tr>
<th>Number of inhabitants</th>
<th>Daily flow</th>
<th>Maximum flow</th>
<th>BOD₅</th>
<th>Total nitrogen</th>
<th>Total phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>800,000</td>
<td>278,000 m³/d</td>
<td>530,000 m³/day</td>
<td>245.9 mg/l</td>
<td>48.0 mg/l</td>
<td>6.59 mg/l</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>BOD₅</th>
<th>Total nitrogen</th>
<th>Total phosphorus</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10</td>
<td>&gt; 80 % reduction</td>
<td>&lt; 0.3 mg/l</td>
<td>&lt; 75 mg/l</td>
</tr>
</tbody>
</table>

### Outgoing wastewater

<table>
<thead>
<tr>
<th>Limit values</th>
<th>BOD₅ (max)</th>
<th>Total nitrogen</th>
<th>Total phosphorus</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
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<td>&lt; 10 mg/l</td>
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</table>

### Chemical consumption

- Ferrous sulphate
- Hydrated lime
- Methanol
- Polymer

### Biogas and energy

- Production of biogas
- Energy consumption in the process
- Total consumption
- Production of energy
- Self-sufficiency in electricity
- Self-sufficiency in heat

### Costs**

- Operating costs: 11.8 ME/year
- Personnel costs: 2.6 ME/year
- Outsourced services: 3.7 ME/year
- Materials and equipment: 4.4 ME/year
- Renovation investments: 3.8 ME/year

*Does not include the further processing of sludge

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* Information from 2015
** Does not include the further processing of sludge
Wastewater treatment plant area

1. Inlet pumping static
2. Screens
3. Sand removal
4. Preliminary aeration
5. Preliminary aeration
6. Aeration
7. Secondary settling
8. Biological after-filtration
9. Methanol station
10. Machine and equipment areas
11. Digestion tanks
12. Intermediate storages
13. Sludge dryer
14. Gas holder
15. Energy station
16. Main building
17. Incoming air
18. Outgoing air
19. Heavy traffic