Energy efficient waste water treatment achieving full nitrifying conditions

In a nutshell

SUMMARY
It is best practice to: • have the installed capacity to treat at least twice the dry weather waste water flow (in case of rain or thawing); • treat the waste water at nitrifying conditions (food to microorganisms ratio of < 0.15 kg BOD5/kg MLSS per day), and perform denitrification and phosphorus removal; • remove suspended solids by means of sand filtration (or by submerged membranes) in the case of sensitive receiving water bodies; • implement other tertiary treatment to reduce micropollutants (see best practice on minimising waste water emissions with special considerations of micropollutants); • continuous monitoring of organic compounds (total organic carbon), ammonia, nitrate and phosphorus in the case of plant capacities of more than 100 000 population equivalents (p.e.) or of a daily inflow BOD5 load of more than 6 000 kg; • stabilise primary and excess sludge in anaerobic digesters (see best practice on anaerobic digestion of sludge and optimal energy recovery); • dry the anaerobically stabilised sludge and send it to incineration (see best practice on drying and incineration of sludge); • adopt energy-efficient technologies, such as energy-efficient fine bubble aeration systems in the biological stage and energy-efficient pumps and screw lifters.
Target group
Public administrations responsible for waste water management and urban drainage.
Applicability
This technique is applicable to public administrations responsible for waste water management, both in new and existing waste water treatment plants.
Environmental performance indicators
• Concentrations in the discharged final effluent or removal efficiencies of COD, BOD5, ammonia, total nitrogen and total phosphorus (mg/l, %) • Electricity use of the waste water treatment plant per mass of BOD5 removed (kWh/kg of BOD5 removed) • Electricity use of the waste water treatment plant per volume treated (kWh/m^3 of waste water treated) • Annual electricity use of the waste water treatment plant per population equivalents (KWh/population equivalents/year)
Benchmarks of excellence

- The removal efficiencies achieved are: at least 98 % for BOD5, at least 90 % for COD, at least 90 % for ammonia, at least 80 % for total organic nitrogen compounds, and at least 90 % for total phosphorus
- The electricity use of the waste water treatment plant is:

  - lower than 18 kWh/population equivalents/year for large municipal waste water treatment plants (with a size of more than 10 000 population equivalents)
  - lower than 25 kWh/ population equivalents /year for small municipal waste water treatment plants (with a size of less than 10 000 population equivalents)

Description

Best practice for energy-efficient waste water treatment is:

- to have the installed capacity to treat at least twice the dry weather waste water flow (in case of rain or thawing)
- to treat the wastewater at nitrifying conditions (food-to microorganisms ratio of < 0.15 kg BOD_5[1]/kg MLSS[1] x d), and to perform denitrification and phosphorus removal
- to remove suspended solids by means of sandfiltration in case of sensitive receiving water bodies or other tertiary treatment such as activated carbon filtration or oxidation with chlorine-free oxidising agents in order to reduce micropollutants such as man-made hormone-disrupting chemicals (see the best practice on tertiary treatment for the removal of micropollutants)
- to monitor on-line organic compounds (total organic carbon), ammonia, nitrate and phosphorus in case of plant capacities of more than 100 000 population equivalents (p.e.) or of a daily inflow of BOD_5-load of more than 6000 kg respectively
- preferably to stabilise primary and excess sludge in anaerobic digesters and to use the produced biogas for on-site electricity production and sludge drying, at least for plants with a capacity of more than 100 000 population equivalents or of a daily inflow BOD_5-load of more than 6000 kg respectively (see the best practice on anaerobic digestion of primary and excess sludge and optimal energy recovery)
- to dry the anaerobically stabilised sludge and to send it to incineration or co-incineration plants (e.g. in coal-fired power plants or cement plants) meeting the standards according to the IED; in case of small plants, the mechanically de-watered sludge can be sent to central sludge drying plants (see the best practice on drying of sludge and its incineration according to BAT standards)
- To use energy-efficient fine bubble aeration systems in the biological stage, to use energy-efficient pumps and screw lifters, to recover biogas from anaerobic digestion of primary and excess sludge and to use it in energy-efficient turbines producing electricity and heat to be fully used for plant operation (see the best practice on anaerobic digestion of primary and excess sludge and optimal energy recovery).

Environmental benefits

The most important environmental benefit is to have clean rivers and natural waters as they are protected from untreated or insufficiently treated waste water in terms of organic impurities (removal efficiency of BOD_5 of more than 98 % and of COD of more than 90 %), inorganic pollutants (heavy metals), nutrients (phosphorus removal efficiency of more than 90 % and nitrogen (removal efficiency of ammonia of more than 90 % and of the sum of inorganic nitrogen compounds of more than 80 %)) and from microorganisms. For a large number of micropollutants, an additional treatment step is required in order to eliminate them at high efficiency (see the technique on the removal of micropollutants).

Side effects

For treating waste water at nitrifying conditions, more energy is required compared to plants which mainly reduce the organic load, specifically electricity consumed for the extended fine bubble aeration in the activated sludge system.

Applicability

This technique is applicable both to new and existing plants. Existing plants can be retrofitted. This is true for the waste water treatment as well as for the measures to minimise energy consumption and to recover energy.

Economics

For the Breisgauer Bucht waste water treatment plant near Freiburg in Southern Germany, described above, total operating costs were EUR 15.5 million in 2012, equating to EUR 0.74 per m^3. Fees charged to users of the sewage network (households, industries) are EUR 1.32 per m^3, one of the lowest in Germany (typical range EUR 1 to 3 per m^3).

The costs for energy efficiency measures usually do pay bay back with 2-5 years (UBA, 2008).

Driving forces for implementation

Legal requirements, cost aspects and demands of the public due to high awareness are the most important driving forces for implementation.

Reference organisations

A considerable number of municipal waste water treatment plants in Northern and Central Europe, such as in Freiburg i.Br., Karlsruhe, Hamburg, Berlin etc. (all Germany), Copenhagen (Denmark), Amsterdam (Netherlands).

Literature

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