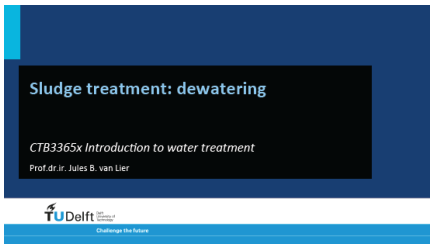
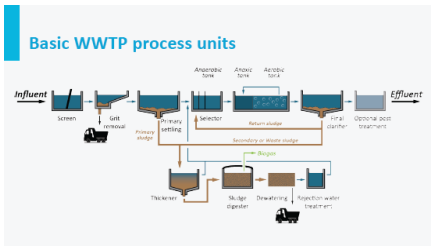
CTB3365x – Introduction to Water Treatment

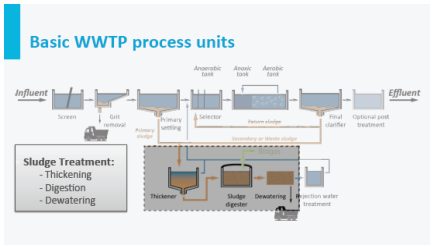
W6c – Dewatering

Jules van Lier

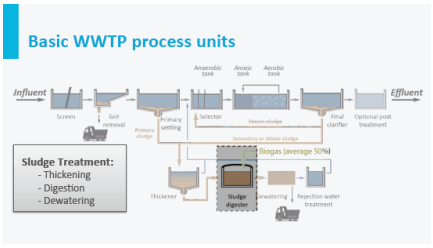




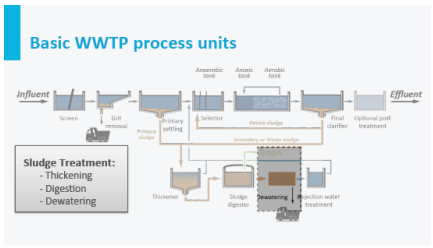
During sludge digestion, the biodegradable organic fraction of the thickened sludge is converted to biogas.



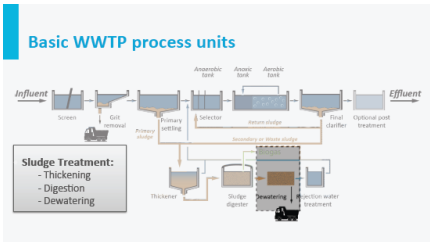
Are we ready for sludge disposal?



In the digester, part of the organic matter is converted to biogas, on average this may reach about 50%. This means that the effluent solids content of the digester is less than the influent.



In the subsequent step the digested sludge needs to be dewatered in order to reduce the sludge volume

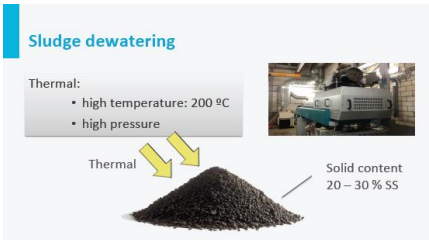


that needs to be transported and disposed off.

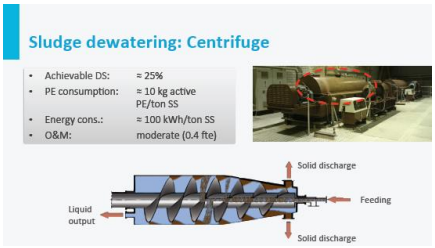
Dewatering is in size only a small unit in the entire treatment plant, but it is crucial for the economics of the plant.

In the Netherlands, stabilized excess sewage sludge cannot be used for agricultural purposes. The heavy metal content in the excess sludge is too high. Since landfills are abandoned, the only outlet for the digested sewage sludge is incineration at extremely high costs. Therefore, most sewage treatment plants are trying to increase the dry solids content of the treated sludge to the highest possible value.

In most sewage treatment plants, a dry solids content between 20-30%, or even higher, is pursued. In order to achieve this value, the digested sludge needs to be conditioned for the dewatering process. Conditioning is done either chemically or thermally. In chemical conditioning chemicals are added to the sludge to improve the electro-chemical interactions between the sludge particles, creating more free water, which is easy to separate. For conditioning, most commonly, lime and ferric chloride is applied in an amount up to 300 g per kg of suspended solids. The downside of using these chemicals is the increase in solids content and the production of large amounts of chemical sludge waste. Alternatively, poly-electrolytes or PE are used, which are generally organic cationic polymers, and which are added in much lower amounts, in the range 3 – 8 g per kg suspended solids. For some dewatering systems, some more PE is required. The purchase costs for these chemicals are much higher but the total sludge mass produced is much less.

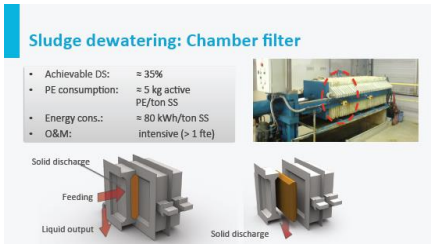


Alternative to chemical conditioning, sludge can be thermally conditioned, applying temperatures up to 200°C and high pressures.

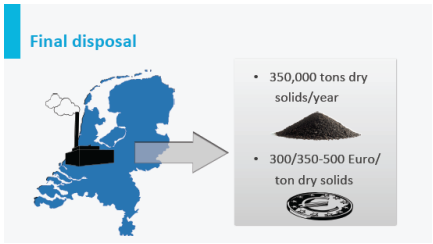


Sludge dewatering is often performed applying continuous centrifugation. With a centrifuge, a final dry solids content of about 25% can be achieved. For sludge stabilization a poly-electrolyte consumption of about 10 kg per ton SS is required, whereas the energy consumption is about 100 kWh/ton SS. Centrifugation requires relatively high personnel attention.

The most common alternative to centrifugation is the filter belt press. Also with a filter belt press, a dry solids content of about 25% can be achieved. However, less PE chemicals are required, generally up to 7 kg per ton sludge. The energy consumption is also a little bit lower, reaching 80 kWh/ton SS and less personnel is required for maintenance.

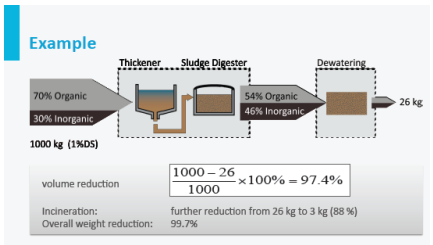


The chamber filter press achieves the highest dry solids content, reaching up to 35%. The energy consumption is similar to the filter belt press, and the chemical consumption reaches about 5 kg PE per ton SS. In some cases, wood chips are added to facilitate the drying process. The downside of the chamber filter press is the high demand for maintenance personnel.



After sludge dewatering, the excess sludge is ready for final disposal. Agricultural use or disposal in landfills is not possible in the Netherlands, meaning that pelletization, gasification or incineration is the only outlet for our excess sewage sludge. In the Netherlands we produce about 350,000 tons of dry solids per year, which is about 16 kg dry solids per person per year. Costs for incineration are about 300-350 € up to even 500 € per ton dry solids, depending on the distance to the incinerator and the percentage of dry weight that can be achieved. As such, the final sludge disposal determines to a large extent the operational costs of our sewage treatment works.

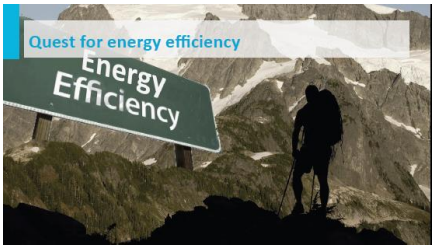
Considering the costs for sludge disposal, sludge volume reduction is very important for operational purposes. The overall sludge volume reduction in the sludge line of the treatment plant is huge but can only be achieved step by step.



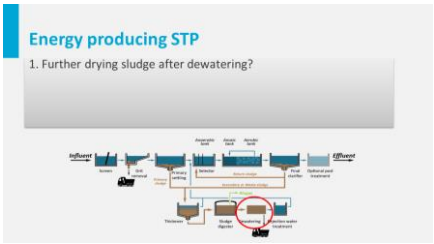
For example, at the start, a sludge stream of 1000 kg has 1% dry solids of which, let's say, 70% is organic and 30% is inorganic. After thickening and digestion, the organic fraction has dropped to 54% and the ash fraction is increased to 46%. Dewatering results in a sludge mass of only 26 kg, meaning a total volume reduction at the treatment plant exceeding 97%! If the dewatered sludge would be incinerated, a further volume reduction of 88% is expected, meaning a total volume reduction of 99.7%.

Next to sludge disposal, energy consumption has a large impact on the operational costs. The total power demand for sewage treatment in The Netherlands is about 60 MW, which is about 40% of the power demand for the entire water chain. Per population equivalent this is about 24 kWh per year or about 2.7 W. Per m3 of treated sewage the energy requirement is 0.25 kWh. Although these numbers are low in value, energy is a limiting factor in many places of the world to install sewage treatment.

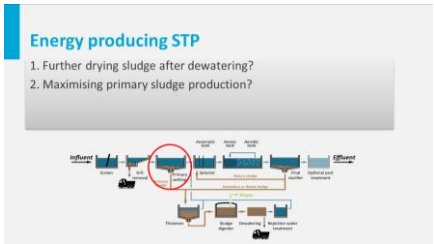
In the Netherlands, the water sector has signed an agreement with the ministry to increase the energy efficiency in the water sector by 2% per year until 2020, which means a total reduction of 30%. Therefore, present research and development is oriented to increase the energy efficiency in sewage treatment processes. Novel technologies for nitrogen removal such as autotrophic denitrification or Anammox process are being developed and implemented. In addition, complete different technologies are being installed such as the aerobic granular sludge process. These novel developments are being discussed further in our master lecture series.



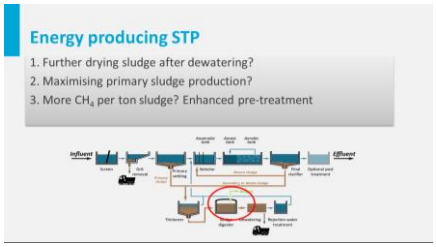
In the quest for energy efficiency, a large focus is put on maximizing the energy recovery from the excess sewage sludge. In principle, all fossil fuel demand could be derived from the energy that is bound in the sewage sludge and the excess sludge from the treatment plant.



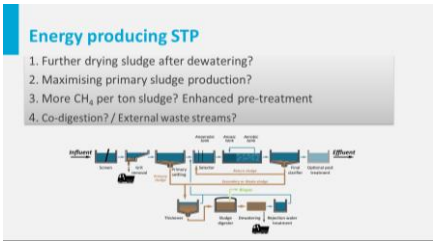
Increased energy recovery from the sludge could be achieved by: 1) Further drying of the sludge, after dewatering by using excess heat from, for instance, the biogas generators. Sludge with a dry solids content of 90% has a heating value of about 10-16 MJ/kg, which is in the similar order of magnitude than lignite, commonly used as a fuel.



2) Maximization of primary sludge production by adding chemicals to the primary clarifier, and thus, increasing the amount of COD that will be converted to biogas in the digester. Meanwhile, less energy is required for oxidation in the aeration tank. Obviously, care should be taken that the nutrient removal capacity of the sewage treatment plant will not be affected.

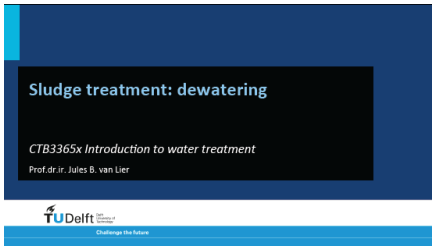


3) During digestion, only 50% of the organic matter is converted into biogas. Apparently, the remainder of the organic matter is not accessible for bioconversion. At present, a number of novel pre-treatment technologies are being developed, such as thermal pressure hydrolysis, which is used to solubilize the sludge in order to make the organic matter better accessible for bioconversion.



4) The sludge digesters at the site of an STP could be used to co-digest external organic matter, for instance, from agricultural sites. The additionally generated energy will then positively influence the energy balance of the STP.

By applying more energy-efficient treatment technologies and by recovering more usable energy from the sewage sludge, the Dutch Water sector is aiming at developing energy neutral, or maybe energy producing, sewage treatment plants.



We now treated both the wastewater and the sludge that is generated during the treatment process. The effluent is discharged to an environmental sink, and the dewatered sludge is conveyed for final disposal or incineration. It was great we could explain the treatment plant set-up to all of you! See you next time!