ANNEX 3: SLUDGE TREATMENT PROCESSES

With the construction and expansion of municipal infrastructure (sewage and wastewater treatment plants), the amount of sludge produced by the wastewater treatment plants is increasing. Sewage sludge is the leading waste by-product of wastewater treatment. The excess sludge presents biomass and microorganisms that contain organic matter, nutrients, and persistent pollutants that originate from wastewater. Usually, it has a low density and low concentrations of inorganic matter. The sludge produced during biological treatment is called secondary (biological) sludge. It can be fermented in aerobic digesters to gain biogas; however, the sludge from anaerobic digesters still has to be further processed and appropriately disposed of.

Besides activated sludge from biological treatment and anaerobic digesters, wastewater treatment plants produce primary sludge. This originates from primary sedimentation tanks designed to remove inorganic particles (sand or gravel) as some more massive organic particles that can precipitate from raw wastewater. The amount and characteristics of primary sludge depend on the sedimentation tank's capacity, hydraulic performance, and of course, on the quality of the influent water.

Sewage sludge treatment describes the processes used to manage and dispose of the sludge produced at wastewater treatment. It typically involves one or more of the following processes: thickening, stabilization, dewatering, drying, and final disposal.[1] The choice of sludge facilities usually depends on the overall final disposition.

Sludge management is an integral part of any modern municipal wastewater treatment plant (Figure 1): it is important to keep the nutrients in the sludge, to make use of its material and energy, and to dispose of it efficiently and sustainably.[2] Usually the focus is on wastewater treatment, while sludge treatment issues (energy consumption, disposal, and reuse) are often neglected.

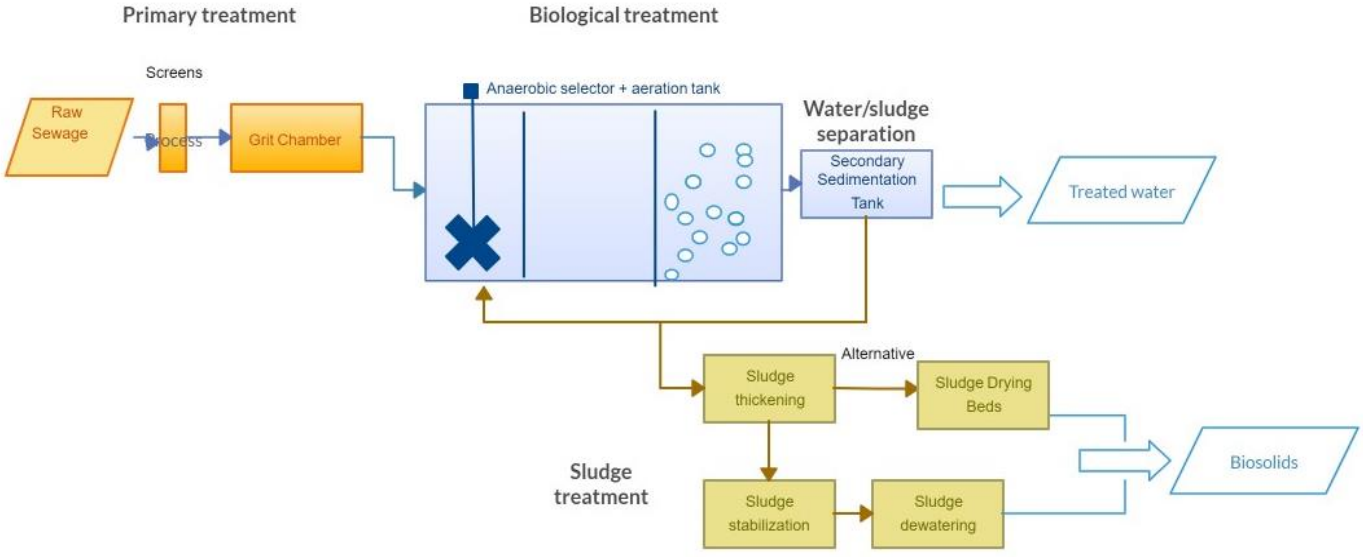

Figure 1: Flow diagram of WWTP

A large number of processes for wastewater treatment makes it sometimes complicated to make a proper choice. The choice of treating wastewater does not depend much on the effluent quality, but

[1] https://ec.europa.eu/regional_policy/sources/consultation/gpp/pdf/draft_eu_gpp_criteria_public_consultation_final.pdf
[2] http://www.purebalticsea.eu/index.php/gpsm:good_practices

on the economics of the whole wastewater treatment plant, including sludge treatment. The choice of the treatment process will always be highly site-specific.

The main processes used for sludge handling may be grouped into stabilization and dewatering treatments. Stabilization treatments aim to reduce the biodegradable fraction of organic matter, thus reducing the risk of putrefaction and diminishing the concentration of pathogens. On the other hand, dewatering techniques are used to decrease sludge volume; hence sludge disposal costs and environmental risks associated.[3]

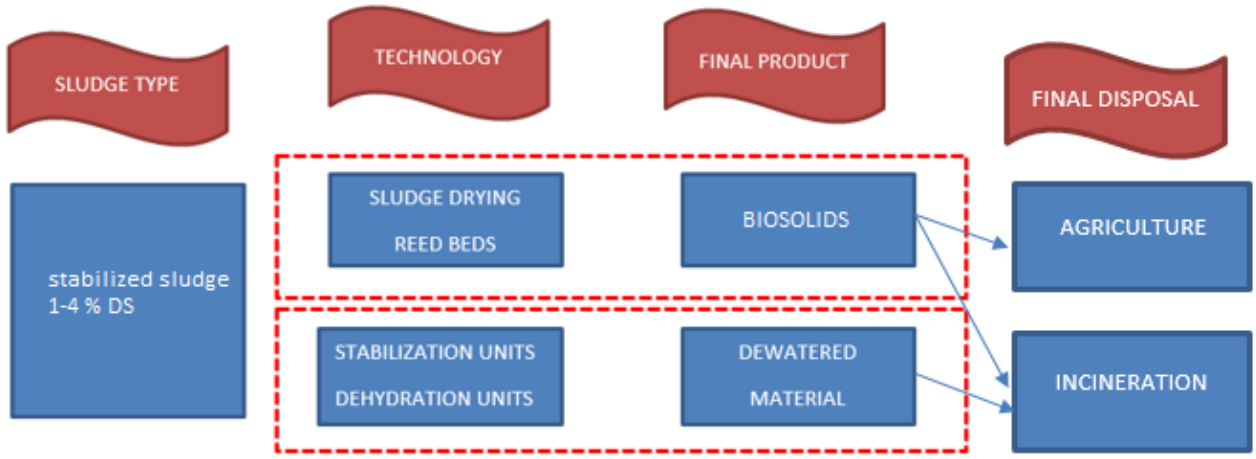

Figure 2: Sludge treatment alternatives

Material produced during wastewater treatment that may be put to beneficial use is termed "biosolids". Biosolids are nutrient-rich organic materials resulting from the treatment of domestic sewage in a treatment facility. [4] They are primarily organic materials produced during wastewater treatment, which may be put to beneficial use.[5] When treated and processed, this by-product can be valorized, recycled, applied as fertilizer to improve and maintain productive soils and stimulate plant growth.[6]This product or biosolids contain essential nutrients that, when properly treated and processed, can be applied as fertilizer to farmland, amend soils improve fertility, and enhance plant growth. Returning biosolids to farmland completes a natural food cycle where farms produce is consumed by humans who then produce biosolids, which, treated appropriately to kill pathogens and enhance the fertilizer value, can be returned to the farms to offset input costs and deliver better yield results. This multi-use product can also be used for sod farming, soil remediation, horticulture, golf courses, and more.[7]

Table 1: Sludge treatment stages

Sludge treatment stages	Description	Method
Pre-treatment	Removal of disturbing solids and contaminants	screening
Thickening	Reduction of water content with physical process of concentrating the sludge	gravity flotation centrifuge belt press

[3] https://gemma.upc.edu/images/downloads/thesis/tesis_enrica%20uggetti.pdf
[4] https://www.epa.gov/biosolids/frequent-questions-about-biosolids
[5] https://www.epa.gov/biosolids/information-biosolids-managers
[6] https://www.epa.gov/biosolids/frequent-questions-about-biosolids
[7] https://lystek.com/what-are-biosolids/

Sludge treatment stages	Description	Method
Pre-treatment	Removal of disturbing solids and contaminants	screening
Stabilization	Stabilization of the biodegradable fraction of the organic matter, reduction of VSS, elimination of odors as well as pathogens reduction	aerobic digestion anaerobic digestion composting alkaline
Conditioning	Preparation for dewatering with increasing sludge dewatering capability.	thermal chemical
Dewatering	Removal of water.	mechanical dewatering drying beds reed beds
Drying	Minimization of sludge mass.	belt dryer solar active dryer drying beds reed beds
Disinfection/hygienization	Removal of pathogenic organisms with thermal drying or solar radiation.	belt dryer solar active dryer drying beds reed beds
Final disposal	Final destination of by-products.	incineration reuse in agriculture

Two standard technological options for sludge dewatering:

- **Mechanical dewatering**: Dewatering is done mechanically using a filter press or centrifuges so that the solids content of the sludge increases to about 20 %.
- **Sludge drying reed beds**: Dewatering and mineralization is done using natural processes. The solid content of the sludge is higher compared to mechanical dewatering. Dry solid content of the treated sludge can be up to 20-40%[8] or even 50%[9] in a warmer climate.

If the wastewater is mainly from households, high concentrations of heavy metals and toxic pollutants are not expected, so the generated sludge can be used for agricultural purposes. In the case of industrial wastewaters, other pollutants may be present and sludge management should be tackled with special attention.

Sewage sludge must be treated due to health, environmental, and economic reasons. Sludge contains different pathogens and toxic pollutants that can cause health problems to the persons exposed to it. Raw sludge also has unpleasant smells and is a potential source of vectors. Therefore, it is necessary to deactivate pathogens and transform substances. Volume reduction is also beneficial in order to reduce costs and makes reuse economically feasible.

[8] https://conferences.aquaenviro.co.uk/wp-content/uploads/sites/7/2018/08/59-Steen-Nielsen-1.pdf

[9] Limnos experience from RBs in Macedonia during commissioning phase (1st year of operation).