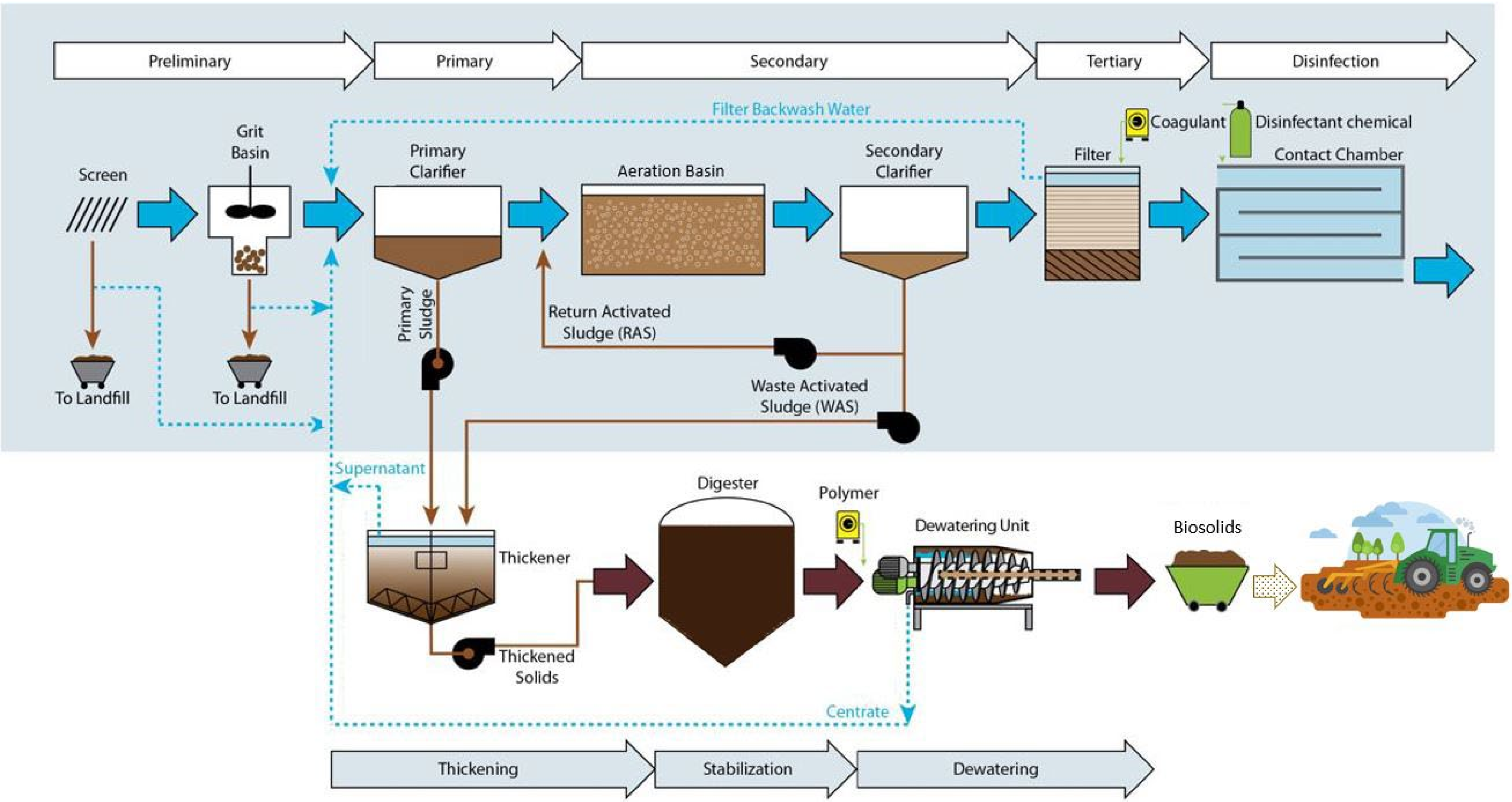
Guidance on Impacts of Typical Treatment Processes on Solids Dewaterability



This is a generic facility process flow diagram. Specific elements and order may differ. Click on icons for more information on the impacts of each process/ element on dewaterability.

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Preliminary Treatment (Screening, Grit removal)

Purpose: To remove large inorganic material and protect downstream mechanical and biological process equipment.

Impact on dewaterability:

- Poor screening can improve cake solids concentration, as fibers and other materials can make it into the solids stream and assist in holding together sludge flocs. Polymer consumption may appear to be lower when reported in kg/t DS (lbs/ton) due to higher quantity of inert material.
- Similarly, fine screening can decrease cake solids due to a lower amount of fibers in the feedstock to the dewatering equipment.
- Large screenings, such as rags, can clog pumps or equipment upstream of dewatering. Weighted check valves, for example, can cause down time for dewatering operations. Some drying systems also require screening or debris removal from dewatering feed to prevent clogging of dryer feed mechanisms.
- Fine screening can remove smaller debris/plastics, preventing it from entering the solids stream and contaminating dewatered sludge. This can have especially large implications when land application of biosolids is desired.
- High quantities of inorganic material from poor grit removal may increase cake solids and decrease apparent polymer dose, as the inorganic material does not require polymer. However, additional grit can abrade/damage pumps, valves, and equipment, especially high-speed units like centrifuges.

Primary Treatment

Purpose: Removal of settleable solids and floating fats, oils, and grease (FOG) from the raw influent wastewater.

Impact on dewaterability:

- Typically, the higher the ratio of primary sludge to secondary sludge by mass in the digester and subsequent dewatering feed, the higher the cake solids concentration and possibly, lower polymer dose.
- In certain cases, advanced primary clarification using chemicals to increase clarification efficiency can negatively affect the dewatering process (higher polymer dose and lower cake solids) and cause scaling in downstream piping. However, ferric chloride, which is often used in advanced primary clarification, can increase cake concentration, and sometimes reduces polymer demand.

Secondary Treatment

Purpose: Through biological and chemical processes, reducing the biodegradable organic matter and, in some areas, nutrients like nitrogen and phosphorous that can impair receiving water bodies.

Impact on dewaterability:

- Waste activated sludge has gel-like, exocellular biopolymers that hold floc together but also trap water, limiting the amount of water that can be released through mechanical dewatering.[2]
- Biocolloidal material (small solid particles suspended within the liquid) impacts polymer demand – if there is more biocolloidal material, the polymer demand will increase.[5]
- Phosphorous removed in the secondary treatment processes can be released if sludge is sent to anaerobic processes downstream (like digestion). Once released in that environment, phosphorous will bind with cations like magnesium. Depending on the cations in the system, this could lead to reduced dewaterability because divalent or multivalent cations help to reduce the water bound inside the floc.[2,4,5,6,7] Additionally, depending on the water chemistry, problematic precipitates, like struvite, may form, which can lead to operational and maintenance difficulties like material buildup in equipment and reduction in flowable area within piping.
- In general, dewaterability is more difficult (defined as higher polymer usage, wetter cake, lower solids capture rate, reduced capacity in dewatering equipment to maintain acceptable performance) in the following circumstances:
    - For solids produced in secondary biological processes than for solids produced in primary treatment because waste activated sludge comprises more protein than primary sludge and protein forms most of the exocellular biopolymer that traps water, making it more difficult to digest and dewater than primary sludge.[4,5,6,7]
    - As the ratio of primary to secondary sludge sent to downstream solids processes skews towards more secondary sludge than primary sludge.[4]

- As facilities upgrade secondary treatment from biochemical oxygen demand (BOD)-only removal to nutrient removal. Facilities that upgrade from BOD removal or nitrogen removal to biological phosphorous removal typically experience a significantly negative impact on dewaterability. [4,5,6,7]
- For solids remaining in the secondary treatment process for a longer time (longer sludge age) because of the generation of more exocellular biopolymers and more opportunity for floc to break apart and generate more biocolloids. [4,5,6,7]

Tertiary Treatment & Disinfection

Tertiary Treatment (Filtration)

Purpose: To improve effluent quality to stringent water quality standards.

Impact on dewaterability:

- Filtration makes dewatering more difficult (higher polymer usage, wetter cake, reduced capacity in dewatering equipment to maintain acceptable performance) because return stream with fine solids must be re-treated.
- Fine solids have greater relative surface area – more surface tension. The greater surface tension causes more water to remain bound to the particles and causes wetter cake.
- Smaller particles pass through filters.
- Some tertiary treatments use alums for coagulation of fine particles. Alum changes solids characteristics – like introducing drinking water residuals – and can negatively impact polymer/sludge reaction.

Disinfection:

Purpose: To inactivate harmful bacteria or micro-organisms to protect the public and the receiving waterbody.

Impact on dewaterability:

- No impact has been identified thus far.

Thickening

Purpose: Thickening is essential to reduce the volume of combined water and solids removed in liquid treatment by separating and removing water from solids. It also increases the solids concentration to reduce the volume of sludge stabilization or other process capacity required for further treatment of sludge solids. For example, thickening a thin sludge stream from 0.2% - 1.5% solids to thickened solids with 2% - 8% solids that still flow like a liquid but require significantly reduced volumetric capacity in subsequent treatment processes.

Impact on Dewaterability:

- The higher the thickened sludge concentration, the lower the hydraulic loading to downstream solids treatment and processing equipment resulting in:
  - Better digestion effectiveness (greater digestion capacity or solids retention time and greater volatile solids destruction).
  - Higher dewaterability of solids.
  - Greater dewatering throughput capacity and flexibility to optimize operations for lower energy consumption and lower overall operating costs.
- If the solids capture rate of the thickening equipment employed is poor (< 90 %), the uncaptured solids in the return stream (e.g., centrate, decanted liquid, filtrate, pressate) may be recycled either through the head of the facility or the secondary treatment system. These recycled solids not only take up secondary treatment capacity but are also costly to dewater as they employ resources, such as, polymer more than once.

Stabilization

Aerobic Digestion

Purpose: Reduce pathogens and vector attraction through stabilization of solids streams via endogenous respiration in an aerated, mixed reactor. The process oxidizes organic material to carbon dioxide, water, and ammonia or nitrates and releases heat due to the process' exothermic nature. This process also reduces odor potential of raw solids and decreases the mass of organics that must then be further treated in dewatering and subsequent processes.

Impacts on dewaterability:

- Aerobic digestion will typically increase polymer demand in dewatering compared with undigested solids but has less impact on cake solids concentration.

Thermal Hydrolysis Pretreatment (Upstream of Anaerobic Digestion)

Purpose: To break down the sludge floc structure using high temperature steam and pressure or caustic and heat from hot water. The processes reduce viscosity, which allows increased loading rates to anaerobic digesters, and may achieve Class A biosolids under certain circumstances.

Impact on dewaterability:

- Typically improves cake solids by 20-50 % as a relative increase (sometimes higher) and increases polymer demand depending on the original feedstock, especially the primary/waste activated sludge (WAS) ratio. [4]
- The return stream (e.g., centrate, filtrate) often contains higher concentrations of ammonia and recalcitrant organics (organic material that is resistant to decomposition), including dissolved organic nitrogen, as well as materials that exert a higher disinfection demand. [1]

Anaerobic Digestion

Purpose: Reduce pathogens and vector attraction through stabilization of solids streams in the absence of oxygen within an enclosed, heated, and mixed reactor. The process biochemically converts organic material into end products like methane-rich biogas and stabilized biosolids that can be beneficially used. This process also reduces odor potential of raw solids and decreases the mass of organics that must then be further treated in dewatering and subsequent processes.

Impacts on dewaterability:

- Anaerobic digestion will typically make dewatering worse compared with undigested solids, resulting in greater polymer demand and lower cake solids concentration.[4,5,6,7]
- The greater the proportion of primary sludge in the digester feed, the greater the decrease in dewatering properties (compared to undigested sludges). For WAS-only digestion, the deterioration in dewatering is much less in comparison.
- The main cause of worsening dewatering is the destruction of materials in primary sludges that are beneficial to dewatering such as fibrous material as well as the change in the cation balance associated with the anaerobic conditions.
- Anaerobic digestion followed by dewatering can also produce a return stream with high concentrations of ammonia and/or phosphorous which can contribute to operational issues like struvite.

Co-Digestion (Within Anaerobic Digesters)

Purpose: Increase biogas production through the addition of external high strength wastes to an anaerobic digester such as fats/oils/grease (FOG), food waste, and similar organics.

Impacts on dewaterability:

- Co-digestion has varied effects on dewaterability.
- In some cases, the dewaterability can improve in terms of cake solids up to a certain loading rate and depending on the type of waste.
- In other cases, the cake solids can decrease with co-digestion depending on the feedstock.
- In most cases, the polymer demand increases with co-digestion.

Dewatering

<u>Purpose</u>: To reduce the volume of combined water and solids removed in liquid treatment by separating and removing water from solids or increasing the solids concentration.

<u>Impact on dewaterability</u>:

- If the solids capture rate is poor (< 90 %), the uncaptured solids in the return stream (e.g., centrate, pressate) may be recycled either through the head of the facility, the secondary treatment system, or a separate centrate sidestream treatment, followed by secondary treatment. These recycled solids not only take up secondary treatment capacity but are also costly to dewater as they employ resources such as polymer more than once.

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