TECHNICAL
BULLETIN

WASTEWATER-
SLUDGE DEWATERING

Sludge is a catch-all term used to denote such diverse waste materials as lime softening residue, precipitated metals, organic debris, silt, sewage biosolids, etc. Most untreated sludges range in solids content between 0.5% and 10.0%. Sludge is considered to be a plant effluent by most states, and consequently, sludge disposal is regulated in a manner similar to liquid wastes. Sludge disposal is generally accomplished by landfill, land application, or incineration. In any case, the sludge must be non-hazardous to the receiving environment. This requires that the sludge be stabilized sufficiently that it will not decompose or leach out water containing pollutants after disposal.

The cost of sludge disposal in a landfill is a function of transportation expense, so removing excess water can have a very significant economic benefit for customers. If the sludge is to be incinerated, excess water also raises the cost, both for transportation and for evaporating off the extra water at the incineration site.

Sludge Dewatering Equipment

Operating (and capital) costs for sludge dewatering can easily be one third of the total wastewater treatment plant budget. Dewatering (or concentrating) sludge involves the use of physical forces of some type to remove the water surrounding the solids in the sludge. Equipment and techniques for sludge dewatering are varied, and may include pressure, centrifugal force, gravity or even vacuum. These may be combined or used in series by designers of dewatering equipment. Polymers are used to assist the separation of water from the sludge. There are basically 6 different types of equipment used to remove free water and floc water from sludge. The efficiency of water removal depends on both the manufacturers' design and on the nature of the sludge. Most units are capable of yielding sludge of at least 20% solids content (also called cake dryness).

Drying Beds are used when both a large area and plenty of time are available for dewatering. The force of gravity is used to pull water through the sludge and then through a sand/gravel support medium (the bed) to a tile drain system. Some evaporation may also take place in a drying bed. Sludge lagoons depend more on evaporation to dewater sludge in them, so they need appropriate climatic conditions. Lagoons and drying beds both are prone to odor concerns.

Gravity Units use the force of gravity as well, to essentially duplicate the process of settling in a clarifier. These units are often described as thickeners, and allow relatively long residence times to encourage settling and compression of the solids, which allows water to rise to the top of the tanks. Some thickeners float the solids and remove water through the underflow, particularly if the solids tend to float naturally. These units must be relatively large to achieve the long hydraulic retention times they require.

Belt Presses (or belt filters) spread the sludge across a rotating filter cloth, allowing gravity (and sometimes vacuum) to remove much of the free water. Once the sludge cake begins to become firm, it passes into a roller press section where additional water is squeezed from the cake by pressure. Belt filter presses are widely used, and are among the most versatile and efficient dewatering equipment available. Belt filter presses almost always require polymer feed to operate efficiently. Flocculants help overcome the hydrogen bonding between solids and water molecules. The polymer molecules help agglomerate the solids into a larger mass (which has a relatively smaller surface area than the smaller precursor flocs) that cannot hold as much water on their surface. Properly conditioned sludge, when added to the gravity draining section of the press, releases a significant amount of free water. This is enhanced by the use of vanes (or plows) on top of the belt to turn the sludge and break out more water. Rollers or foils beneath the belt also help release more water by breaking the surface tension. After the free water drainage section, the belt carries the sludge into the final zone, in which it is compressed between two belts into a “sandwich.” In this final zone, the sludge is subjected to increasing mechanical pressure and changes in direction to promote additional water removal.

Plate and Frame filters operate in a batch dewatering process. Sludge is pumped at high pressure (up to 250 PSI) into a series of relatively small chambers covered with filter cloth. The cloth retains the solid particles but allows the water to squeeze through under the pressure of the system. After a predetermined time period, the pressure is removed, the plates are separated, and the dry cake is removed from the cloth (often using compressed air.) To enhance filtration, a “precoat” (often diatomaceous earth or lime) may be pumped onto the filter cloth first. This helps capture very small solids particles. Sludge storage tanks are required to accumulate sludge between batches.

Vacuum Filters operate by drawing water out of sludge through a porous medium and removing the dry cake by means of scrapers (doctor blades.) Vacuum filters typically use a precoat to increase solids retention. Configurations including disc, pan, horizontal belt, and rotary drum type. In the most common configuration, a rotary drum filter, a perforated drum with a filter cloth around it is partially submerged in a tank of the sludge to be dewatered. As the drum rotates, the vacuum inside the drum draws liquid through the filter cloth, trapping solids on the surface. As the drum continues to turn additional solids may build up until the drum rotates into the air, where additional cake drying takes place. Key operational variables include the vacuum strength, the fraction of the drum submerged, the rotational speed of the drum, and the amount and type of precoat used.

Centrifuges separate solids from the liquid by using centrifugal force to simulate high gravity conditions. There are many design types, including solid bowl (or scroll,) basket, and disk nozzle type centrifuges. These devices place enormous shear stress on the floc going through them. This shear can break flocculant polymer molecules into smaller pieces.

Water Types
There are different types of water trapped within sludges, as described in the chart below,

Water Form	Description	% of Total Water in Sludge	Forces Used to Remove Water
Free Water	Not attached to the solids	Up to 75%	Gravity, Centrifugal, Vacuum, Pressure
Floc Water	Trapped within the sludge structure	Up to 20%	Vacuum, Centrifugal, Pressure
Capillary Water	Adhering by physical attraction to the sludge solids	Varies	Pressure
Bound Water (Particulate Water)	Chemically bonded to the sludge	Varies	Cannot be removed.

Troubleshooting

Below are tables illustrating possible causes of common issues found in vacuum filters and belt presses along with a list of possible solutions for these conditions.

Vacuum Filters

Observations	Possible Causes	Solutions
Low cake dryness	Low feed solids	Improve thickening operations upstream of filter
Low cake dryness	Septic sludge	Increase dewatering frequency
Low cake dryness	Cake too thick on drum	Reduce sludge level in tank
Low cake dryness	Drying cycle too short	Decrease drum speed
Low cake dryness	Improper chemical dose	Optimize dosage of polymer
Poor solids capture	Low feed solids	Improve thickening operation upstream of filter
Poor solids capture	Improper chemical dose	Optimize dosage of polymer or filter aids
Poor solids capture	Cloth weave too open	Evaluate new filter materials
Filter media binding off	Grease/scum/oils in sludge	Improve grease/scum/oil removal upstream
Filter media binding off	Cloth weave too tight	Evaluate new filter materials

Belt Presses

Observations	Possible Causes	Solutions
Low cake dryness	Sludge flow excessive	Adjust flow rate
Low cake dryness	Belt speed too high	Reduce belt speed
Low cake dryness	Improper chemical dosage	Optimize polymer dosage
Excessive belt wear	Roller not aligned	Adjust roller
Belt blinding	Sludge buildup	Repair sprayers
Belt blinding	Sludge buildup	Adjust doctor blade to remove more solids
Belt blinding	Chemical overdose	Decrease polymer dosage
Solids in filtrate/ Low solids recovery	Improper chemical dosage	Optimize polymer dosage
Solids in filtrate/ Low solids recovery	Solids squeezing through filter	Adjust belt speed/tension
Solids in filtrate/ Low solids recovery	Flow is excessive	Reduce flow to the press
Puddling	Improper chemical/dose	Select appropriate polymer and optimize dosage
Puddling	Insufficient mixing of sludge with polymer	Increase mixer speed; move polymer feed point further upstream

Calculations

Here are some frequently used calculations used in sludge dewatering applications:

Calculating Polymer Dosage:

1. Determine sludge dry solids flow in tons per hour:

   (Flow rate (in GPM) X 60 minutes /hour * Weight fraction dry solids in feed sludge * 8.34 pounds/ gallon) / 2000 pounds per ton = dry tons per hour

2. Determine polymer feed rate in pounds per hour:

   Flow of polymer feed (GPM) * 60 minutes/hour * Weight fraction polymer feed solution * 8.34 pounds/gallon = Pounds per hour

3. Calculate polymer dosage in pounds per dry ton:

   Pounds per hour (from step 2) / dry tons per hour (from step one) = pounds per dry ton

EXAMPLE: 100 GPM of a 3% solids sludge is being treated with 2 GPM of a 0.5% polymer solution.

1. 100 Gal./Min. X 60 Min./hr. X 0.03lbs./lb. X 8.34 Lbs./Gal.) / 2000 lbs./ton = 0.75 tons per hour
2. 2 Gal./Min. X 60 Min./Hr. X 0.005 lbs./lb. X 8.34 Lbs./ Gal. = 5 Pounds per hour
3. 5 Pounds per hour / 0.75 tons per hour = 6.67 pounds per dry ton