Understanding the treatment of water plant residuals

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In recent years, "residue management" has become a common term in the water industry. As environmental awareness continues to drive engineering projects, more stringent regulations are being imposed. Therefore, it is critical for the industry to understand the basic concepts behind the process and the regulations that govern the treatment of water residuals.

Residuals consist of settled sludge from preliminary treatment, and backwash wastewater from filtration in the water treatment process. Their discharge is regulated by effluent limits; the extent to which the material is treated is highly dependent on whether it is sent to surface waters or the sewer system.

Discharge to the sewer system is the cheapest method of residue management and requires only equalization of the flow prior to discharge. Slightly more advanced systems provide an extra step for thickening. In these situations, the supernatant (the liquid above the precipitate) is sent to a body of water and the settled materials are transferred to the sewer system. The third option, which is the basis of the process design described here, returns supernatant to a watercourse but captures and dewaters the settled sludge, producing a dry "cake" for disposal.

For discharges into the environment, process residuals are generally treated for total suspended solids (TSS) and chlorine. Chlorine concentration varies according to the amount of residual that each facility applies.

The solids that comprise the residual material are products of the source water and chemical additives used to aid in its treatment. The term "solids," although common to the practice, can be deceptive. Settled sludge, from either a conventional flocculation and sedimentation system or a mechanical clarifier, can be described as a pumpable slurry made up of roughly 3-5% solids, while the filter backwash, usually less than 0.1% solids, is, essentially, turbid water.

Legislation

The *Ontario Water Resources Act* stipulates that the Ministry of the Environment (MOE) has the authority to order the owner of a water treatment plant to provide whatever means necessary to prevent discharges that may be harmful to a watercourse. These orders are upheld in the site-specific Certificate of Approval (C of A). Benchmark values used by the MOE to create these discharge limits are the Provincial Water Quality Objectives (PWQO).

These limits were introduced with the overall goal of ensuring that Ontario's surface waters remain safe for aquatic life and recreational purposes. PWQOs are not legal standards unless they are included in the C of A.

Treatment plants that do not currently treat residues are fixed to a caveat in the C of A that specifies a deadline for the facility to make the necessary upgrades to meet more rigorous effluent criteria. Although rare, there are water treatment plants in Ontario that do not treat residues and were not given such a deadline. Nevertheless, these plants do not have complete freedom; rather, they are intermittently required to conduct studies to characterize the nature of their discharges in order to determine if residue management is necessary.

Process design

Although the process of managing water treatment residuals is often compared to sewage treatment, there are significant differences in the influent chemistry and, accordingly, the treatment processes. As mentioned, residue management facilities are concerned with a number of impurities, but the removal of TSS and chlorine are the priorities. Conversely, municipal wastewater treatment

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plants, in addition to TSS, are required to remove contaminants such as nitrogen, phosphorus and biochemical oxygen demand (BOD). As an example, Ontario's wastewater is usually composed of 200-250mg/L of BOD, compared to just 10-20mg/L in water treatment residuals.

A typical residue management facility will employ chemical conditioning, thickening and dewatering. Plants will also utilize an equalization tank at the inlet of the facility to accept filter backwash, clarifier sludge and the liquids extracted by dewatering. A sludge holding tank may also be used prior to dewatering to ensure a consistent sludge concentration and to provide storage that allows flexibility in equipment operation.

There are many proven technologies available for treating residuals. A designer should be prepared to evaluate them to optimize the process. Some of the most common treatment technologies, with proven results of producing a dry cake, are presented here. Given that the most common form of cake disposal is to landfill, a drier product can drastically reduce tipping fees for the owner.

Chemical conditioning

The quantity of solids that can be extracted from the residue management process depends on two main factors. The first factor is the chemical coagulant used to agglomerate the solids. The second is the quality of water that enters the water treatment plant.

Since a designer is often fixed to a water source, it is easier to adjust the dose or concentration of chemical compounds to suit subsequent processes. Typical coagulants include aluminum sulphate (alum), ferric chloride, ferrous chloride and polymers. Each reacts differently under various process technologies, but polymers tend to be most favourable when mechanical dewatering is employed. Jar tests should be conducted to establish the most suitable coagulant for the conditions.

The coagulant assists in particle settling by eliminating the particles' colloidal properties. When the negative charges that inhibit sedimentation are removed, solids are allowed to agglomerate and settle. Flocculation, or gentle agitation, should be provided to give the particles ample opportunity to come together. A coagulant is also added following thickening to improve the efficiency of the dewatering equipment.

Example of dry cake.

Thickening

Following coagulant addition and flocculation is the thickening stage. Thickening improves dewatering capabilities by increasing the solids concentration. A removal rate of approximately 95% with a solids concentration of up to 6% is achievable through most technologies.

Historically, standard gravitational thickening has been most successful for water treatment residuals, but other technologies worth exploring are solids-contact, ballasted flocculation and dissolved air flotation (DAF) thickeners. Pilot studies are recommended to find the optimum thickening process.

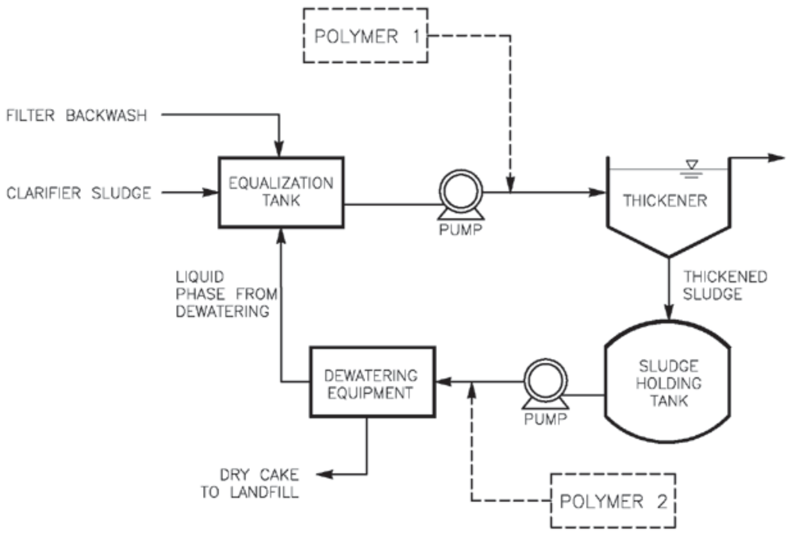
Standard gravitational thickening involves separate units for coagulation, flocculation and settling. The requirements of a large footprint and relatively high residence time are often determined to be acceptable trade-offs for proven success in achieving a high percentage of solids. Typical results for these systems are 4-6% in solids concentration. They are simple to operate and have relatively low operating costs.

Solids-contact thickening is an emerging technology that, through years of improvement, has become a financially feasible solution to residue management. It combines rapid mix coagulation, flocculation and clarification in a single, compact unit and is able to operate under high hydraulic loadings. Recirculating the sludge offers excellent savings in coagulant dosing, while a sludge blanket is responsible for providing better flocculation.

The ballasted flocculation system is a process that uses both chemical and physical means to thicken the influent. An anionic polymer and a continuous supply of coagulant are utilized to encourage the settling of suspended solids by combining the floc. The coagulant used is microsand, which is recycled through the system. A hydrocyclone delivers the centrifugal force required to separate the microsand from the sludge. Financial savings resulting from the high-quality sludge can be lost in excessive operational costs if the recycle rate of the microsand is not maintained.

DAF also requires that all particles undergo coagulation and flocculation. While the goal of gravity settling is to produce large, heavy floc, DAF incorporates flocculation to produce many smaller particles that float to the surface via fine bubble aeration. Sludge that is collected at the top of the tank is easily removed with a skimmer.

This form of treatment is particularly effective at removing solids with low specific gravity and other characteristics such as turbidity, colour and algae. It is also known to remove powerful odours and operate with low retention times and, therefore, a much smaller tank. Operational



Typical process diagram for a residue management facility.

costs for compressed air and polymer dosages must be considered in the design.

Dewatering

Pilot studies are generally the best method for finding the most effective dewatering mechanism. Some of the most common forms of dewatering equipment include a belt filter press, centrifuge, and plate and frame filter press. Sand drying beds were used in the past but have been phased out of designs, as increased flow volumes require a very large footprint for the beds.

The belt filter press design is based on a very simple concept. Sludge is compressed between two tensioned, permeable belts and is forced over and under various rollers. For any given belt tension, as roller diameter decreases, an increase in pressure is transferred to the sludge, squeezing out the water to achieve a total cake solids concentration of up to 25%. To prevent common problems, plant operators are required to monitor the equipment consistently for broken belts and clogged pores.

Centrifugal dewatering uses high-speed rotation of a cylindrical bowl to force the water out of the solids. It operates as a continuous feed system, with the solids being removed by a scroll conveyor and discharged, while the liquids flow out over a weir. Results vary with centrifuge dewatering, reaching as high as 30% solids concentration but as low as 15% or worse for alum sludge.

Downfalls of this method include its susceptibility to corrosion, abrasion and wear. Furthermore, energy requirements are much greater than for other options. It does, however, offer continuous operation with minimal operator attention following start-up.

The plate and frame press is one of the most common forms of dewatering on the market today. The driving force behind this dewatering mechanism is the pressure differential. The reason this process is used so widely is because it produces a drier cake than any other dewatering technology. Previous installations have achieved 30% total cake solids and better. The main advantages to this equipment include savings in landfill tipping fees, adaptability to a variety of solids characteristics, high mechanical reliability and high filtrate quality.

Summary

Given the adaptability and success of today's thickening and dewatering technologies, the discharge criteria established by Ontario's MOE are more achievable than ever. Those directly involved in water treatment are inherently familiar with the legislation and processes behind the practice. It is now time for others in related industry applications to take the time to understand this specialized field, as residue management will continue to be at the forefront of water treatment designs.

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