Innovations in Dewatering Sludges

Wastewater treatment plant owners and managers must contend with high costs of processing and hauling sludge or biosolids. The weight and volume of sludge is a significant cost factor, so it stands to reason that effective sludge dewatering processes will lead to increased savings.

This project provides managers and operators with a fundamental understanding of how to improve sludge dewatering. The project was based on the theory that the structure of flocs dictates the amount of water trapped within them. The binding of water to sludge—and its eventual release from the sludge—depends on kinetic and equilibrium properties, which, in turn, rely on pressure.

This project analyzes current dewatering technologies and evaluates new water removal innovations that disrupt water binding mechanisms. A rigorous survey of the literature and evaluation of two bench-scale pressure filtration techniques give the researchers a strong foundation to identify why and when flocs are formed and destabilized with advanced dewatering capability and what dewatering and conditioning methods are optimal for use in specific situations.

Conditioning and Dewatering Review

The literature review outlines the fundamentals of dewatering, including a history of various technologies. The review provides a revealing look at the scope and limitations of many of the conditioning and dewatering techniques in use.

The team evaluated sludge conditioning and pretreatment methods on the basis of whether they improved sludge floc characteristics, destroyed the sludge cell's exocellular polymers, or contributed to microbial cell lysis that released the cell's water content.

In general, the most successful techniques alter the nature of the solid and water floc structure to improve its dewaterability. The most reliable of these conditioning techniques is freeze-thaw

CSIRO's Bench-Scale Piston Filter Press.

conditioning, a reliable but expensive process. Thermal conditioning was another candidate for improving dewatering filterability or kinetics.

Looking at how sludge cakes best shed their water content (Table 1), the research team concluded that the base mechanism of each of the dewatering systems involves pressure.

Floc Structure and Water Release

The structure of flocs dictates the amount of water that is trapped within them and how this water is released during dewatering. To find the optimal combination of structure and technique, the researchers characterized the floc size, compactness, and strength of sludges, and then correlated these with their response to pressure filtration.

Through the use of two bench-scale pressure filtration techniques—to determine the compressibility and permeability of the cake network and to measure the dynamic rate and extent of expression under increasing pressure (simulating a belt-press filter)—the researchers show that the biofloc structure influences the residual amount of water in the cake more than floc or superflocculated structures. It follows that exocellular polymers may be an important limiting factor in achieving high cake solids.

Anaerobically digested sludge exhibit-

BENEFITS

- Proposes a tool to select the appropriate dewatering device for sludge by quantifying its compressible nature.
- Explains why dewatered sewage sludges might release water after appearing to be dewatered.
- Demonstrates that the electrodewatering technique is applicable to a wide range of sludges.
- Provides evidence that biofloc structure influences the residual amount of water in the cake rather than floc or superflocculated structure.

RELATED PRODUCTS

Understanding Factors Affecting Polymer Demand for Conditioning and Dewatering (01CTS1)

Polymer Characterization and Control in Biosolids Management (91ISP5)

Guidance Manual for Polymer Selection in Wastewater Treatment Plants (91ISP5)

Biosolids Management: Assessment of Innovative Processes (96REM1)

Investigating the Effects of Electrical Arc Pretreatment of Biosolids (97REM4)

Thickening and Dewatering Processes: How to Evaluate and Implement an Automation Package (98REM3)

New Tool for Measuring Biosolids Floc Strength (01CTS32ETA)

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ed the highest cake solids content. The mixed liquor and thickened waste-activated sludges and aerobically digested sludges were similar.

Dewatered sludges are thixotropic, that is, they release water after they appear to be dewatered. It has been shown that time is more important than pressure in achieving high cake solids contents. It has been inferred that applying a high pressure too early in the dewatering process forms an impermeable layer of cake through which the rest of the cake water needs to flow. The challenge is to find ways to overcome this, including:

- removing as much water as possible before the cake forms,
- preventing, or minimizing, the layer(s) of impermeable cake from forming,
- shearing the sludge so the water to be removed does not need to pass through the impermeable layer(s), and
- adding another driving force to help water pass through the impermeable layer(s).

Techniques to Improve Sludge Dewatering

Conditioning and dewatering regimes focus on modifying the microbes, the bioflocs, and the flocs to be dewatered. Pressure filtration and electrodewatering most actively enhanced moisture reduction from sludges. The researchers also assessed combined novel conditioning and novel dewatering techniques.

Sludge that had been frozen and then thawed appeared to have different bioflocs, settled much more quickly than the nonfrozen sample. Once flocculated, this thawed sludge settled to a smaller volume and seemed to hold together better in a simple slump test. It dewatered much better, with the initial dewatering being faster and achieving a higher solids content.

Electrodewatering of the thawed sample reached a significantly higher final solids content than for the nonfrozen sample. For equivalent power consumption, the thawed sample reached higher solids contents. The onset of the electro-osmotic effect in the thawed sample was immediate, which appears to have reduced the initial power consumption required to reach high solids contents.

Freezing, however, is expensive. The challenge is to identify a more economical means than freezing for altering the dewaterability of sludge.

Table 1. Summary of Mechanisms, Advantages, and Disadvantages of the Dewatering Devices Considered

Dewatering Methods	Mechanism and Advantages	Disadvantages
Belt-Press filter	Pressure and shearing Simple, visual process	Good flocculation vital Often operated with high hydraulic loads or low residence times
Filter press	High pressure without shearing	Semicontinuous (but automated)
Solid-bowl centrifuge	High G forces and high shearing	Often operated with high hydraulic loads or low residence times
Vacuum drum filter	Low pressure without shearing	Low throughput or low cake solids contents
Hyperbaric filters	High pressure without shearing	Low throughput or low cake solids contents
Screw press	High pressure and high shearing, Low capital costs	Low throughput or low cake solids contents Prefers high solids contents
Tube press	Very high pressure without shearing	Semicontinuous (but automated)
Wring alternating press	High pressure and high shear	Prefers high solids contents. Low throughput or low cake solids contents
Electrodewatering filter press	Electric field promoting electro-osmosis and heating for moisture removal High pressure without shearing	Electrical costs–but offset by high solids Semicontinuous (but automated)
Thermal filter press	Heat and vacuum promoting moisture removal. High pressure without shearing	Electrical costs–but offset by high solid Semicontinuous (but automated)
Centridry centrifuge	Combined thermal drying and dewatering	Energy costs–but offset by high solids Additional flowsheet unit operations vital
V-fold belt-press filter	Tolerates poor flocculation Pressure and shearing Simple, visual process	Low throughput
Rotary press	Tolerates poor flocculation High pressure and shearing Simple, visual process	Possibly low throughput
Electrodewatering belt-press filter	Electric field promoting electro-osmosis and heating for moisture removal Pressure and shearing	Still under development Electrical costs–to be offset by high solids
Impulse dewatering	Combined heat and mechanical pressure promoting moisture removal	Development stalled due to low throughput

Conclusion

A treatment plant's ability to dewater sludges depends on the specific dewatering process used by the plant and its ability to impact the nature and structure of the sludge particles. Pressure filtration and electrodewatering significantly enhanced moisture reduction, but may not always be cost effective.

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