Understanding Factors Affecting Polymer Demand for Conditioning and Dewatering

Wastewater treatment plants rely upon thickening and dewatering processes to reduce the volume of biological sludges. Currently, synthetic organic polymers are the most commonly used conditioning regimen, but they are expensive, and their costs often represent a significant portion of operational costs at treatment facilities. Improved bioflocculation and a better understanding of sludge properties that generate polymer demand could decrease the need for conditioning while improving cake solids, throughputs, and captures.

Over the past few decades, much research has been conducted on the effect of sludge characteristics, shear, and polymer selection. No other study, however, has incorporated biocolloid concentration, shear, and polymer characteristics into a single predictive model. This study provided a large data set and used consistent testing protocols to examine the three factors independently. The resultant model is a good starting point for attaining the goal of an accurate universal model to predict polymer demand that also can be used as an analytic tool to develop methods for reducing polymer demand and minimize costs associated with dewatering operations.

Biocolloids

Sludges consist of organic, inorganic, and microbial matter held together in a matrix, known as a floc. The flocs that form in activated sludge systems and after aerobic or anaerobic digestion contain significant quantities of water. Typically, such flocs do not thicken and dewater well without addition of conditioning chemicals, such as ferric chloride (with or without lime) or cationic polymers, or without use of centrifuge or belt filter presses.

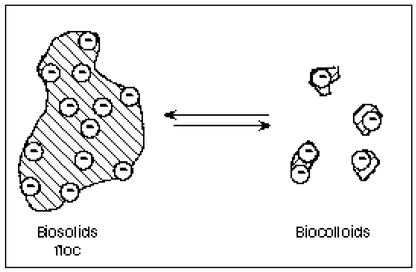

Figure 1. Reaction 1, Showing the Unattached Biocolloids and the Floc in Solution.

Flocs are held together by exocellular biopolymers, which are mainly protein and polysaccharide that are negatively charged. Though most of the biopolymer remains within the floc, pieces of the floc can become dislodged, forming unattached particles called biocolloids (Figure 1).

Charge neutralization is the main mechanism for condition, and the amount of polymer required for effective dewatering depends on the quantity required to obtain a zero charge on the anionic colloidal particles. As the equilibrium in Reaction 1 shifts toward the right, the concentration of biocolloids increases. The colloidal fraction generates the greatest difficulty in dewaterability. The interaction between cationic polymer and biocolloids is shown in Figure 2.

The greater the concentration of biocolloids, the greater the surface area and polymer demand because of the increased surface charge to be titrated.

Until now, no research has examined the differences in polymer demand for different sludges from different processes, and from different plants using the same digestion process. The model developed for this project will allow utilities and practitioners to predict polymer demand based on fundamental characteristics.

Applying the Research

The results of this research and the

BENEFITS

- Examines the impact of charge density, molecular weight, and structure on polymer demand.
- Characterizes the shear sensitivity for sludges from different digestion processes and undigested sludges.
- Develops the first model to predict polymer demand given digestion type, polymer characteristics, and dewatering device.

RELATED PRODUCTS

Innovation in Dewatering Sludges (02CTS3)

Biosolids Processing Modifications for Cake Odor Reduction (03CTS9T)

Effects of Solids Properties on Membrane Bioreactors and Solids Processing (01CTS19UR)

Enhancement of Conditioning and Dewatering Processes by Electrical Arc Pretreatment (97REM4)

RELATED ONGOING RESEARCH

Challenge: Optimization of Wastewater and Solids Operations (OWSOI)

Evaluation of Processes to Reduce Activated Sludge Solids Generation and Disposal (05-CTS-3)

AVAILABLE FORMAT

Soft cover and online PDF.

TO ORDER

Contact WERF at 703-684-2470 or visit www.werf.org and click on Publications.

WERF Subscribers: Your first copy of this report is free. Additional copies are $10 each or download unlimited free PDFs at www.werf.org.

Non-Subscribers:
Hardcopy: $175 PDF: $50

Refer to: **STOCK NO. 01CTS1**

For more information, log on to **www.werf.org** predictive model that was developed could lead to concrete approaches for decreasing polymer demand, which is influenced by three main parameters: biocolloid concentration, shear, and polymer characteristics. This research provides new insights into the effects of different sludge types, different polymer types, and various dewatering technologies. In addition, the report offers several case studies demonstrating some approaches for modifying these parameters and thereby reducing polymer demand.

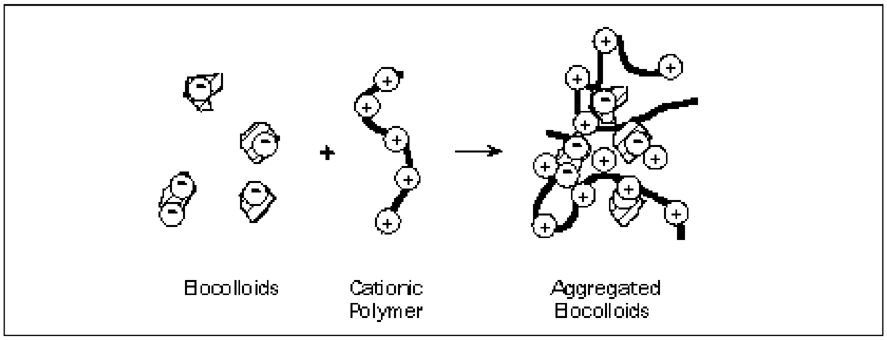

Figure 2. Reaction 2, Depiction of Unattached Biopolymer and Cationic Polymer Resulting in Coagulation.

Biocolloid Concentration

The researchers demonstrated wide variability in biocolloid concentration for different digestion types. Thermophilic digestion processes resulted in much greater biocolloid concentrations than mesophilic digestion processes—both aerobic and anaerobic. Therefore, increased temperatures during digestion will lead to greater biocolloid formation and, consequently, to greater polymer demand. Furthermore, the researchers showed that thermophilic sludges were more sensitive to shear, which can further increase polymer demand.

Another possible method to reduce biocolloid concentration is addition of chemicals and amendments to promote the degradation of biocolloids or bind or neutralize the biocolloids such that they do not consume polymer. The report describes roles of such additives as enzyme mixtures, ferric chloride, and alum, as well as physical means, such as thermal hydrolysis, acid treatment plus thermal hydrolysis, and peroxide.

Shear

Shear during conditioning and dewatering increases polymer demand. Laboratory and full-scale studies showed that operations can be adjusted to minimize shear and, therefore, polymer demand. For example, polymer should be added at locations that minimize the shear through piping systems as well as the entrance zone of a centrifuge. Similarly, reducing torque can reduce polymer demand although there might be a tradeoff with cake solids control. Plants would have to examine their particular situation and balance polymer costs with disposal costs to determine the most cost-effective operational parameters.

Polymer Characteristics

Another avenue for reducing polymer demand is through selection of the polymer and control of polymer dosing. Research has focused on optimizing polymer demand through feedback control to maintain a consistent product and minimize polymer dosage. This research and other work has indicated that high-molecular-weight polymers are needed to adequately condition sludges. Additionally, structured polymers might perform better under high-shear conditions. Other investigators have demonstrated that use of dual-polymer conditioning can improve dewatering characteristics of sludges but without reduction in overall polymer demand.

Future Research

During the course of this project, the researchers found that shear during conditioning (liquid shear) differed from shear during dewatering (cake shear). In fact, shear on the cake might have a larger effect on cake quality in terms of odor production compared with shear of the liquid during conditioning. If the shear experienced by the cake could be replicated in the laboratory, the relationship between cake shear and polymer demand could be modeled, providing a means to understand variables that affect floc properties, polymer demand, and product quality—all important factors for facility operators who are concerned with maintaining product quality in terms of cake solids and odor characteristics.

CONTRACTOR

Matthew J. Higgins, Ph.D.
Bucknell University

Sudhir N. Murthy, Ph.D., P.E.
District of Columbia Water & Sewer Authority

Yen-Chih Chen, Ph.D.
Bucknell University

PROJECT SUBCOMMITTEE

John T. Novak, Ph.D., P.E., Chair
Virginia Tech

Mohammad Abu-Orf, Ph.D.
Siemens Water Technologies

Don Hahn, P.E.
Procter & Gamble (Retired)

David Lordi, Ph.D.
Metropolitan Water Reclamation District of Greater Chicago

Ernest Mayer, Ph.D.
DuPont Engineering

Ronald B. Sieger, P.E., DEE
CH2M HILL

P. Aarne Vesilind, Ph.D., P.E.
Bucknell University

05/08