Design of an In Situ Dissolved Air Flotation System for Beaver Lake

Drew Stephens, Hailey Flatte, Andrew Shaw, Bailey Smith, and Dr. Scott Osborn, P.E.

DEPARTMENT OF BIOLOGICAL AND AGRICULTURAL ENGINEERING

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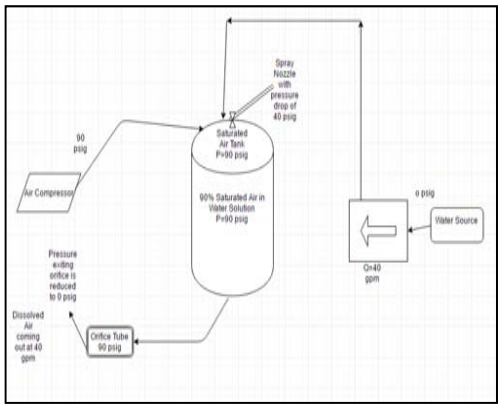
THE PROBLEM

Our client, Beaver Water District (BWD), wants to minimize the amount of Disinfection By-Products (DBPs) being formed in their water treatment facility because they are difficult and costly to remove. Beaver Lake is the main source of drinking water fro Northwest Arkansas, and BWD's intake pipes are an area of concern with respect to their water treatment process. Currently, the undissolved organic matter is removed by adding a liquid Chlorine solution to the water. Hypochlorous acid is formed when the liquid Chlorine solution is added to the water, and reacts with the undissolved organic matter in the water such as algae, and the reaction produces DBPs. The DBPs that are formed include the four primary Trihalomethanes which are CHCl_3, CHCl2_Br, CHClBr_2, and CHBr_3. The intake area is tested once a week for various parameters that measure water quality, but the main parameter we are looking at is the Chlorophyll-a level. This indicates algae concentration in water. If we can reduce the amount of Chlorophyll-a in the water surrounding the intake pipes, the amount of algae will be lowered and therefore the amount of DBPs being formed will decrease.

PROCESS FLOW DIAGRAM



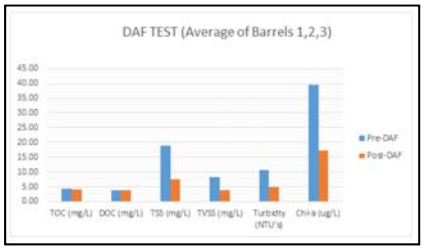
THE PROJECT

Dissolved Air Flotation (DAF) is a water treatment technology used for removing suspended solids, oils, and other contaminants. Pressurized air is injected into water and dissolved. It is then released from solution while in contact with the target contaminants. Air bubbles form and attach to the contaminants and float to the surface due to an increase in buoyancy. Properly designed DAF systems produce a large amount of uniformly sized, microscopic bubbles. DAF is mainly used for drinking water systems, wastewater treatment systems, desalination, poultry processing, and meat processing. Our goal is to utilize a DAF system in Beaver Lake to float algae up to the surface in a defined area around the intake pipes. Our system will decrease the amount of algae that flows into the plant, which could reduce the amount of chlorine being used to treat the water. This in turn will limit the amount of DBPs being formed, and will then cut down on treatment chemicals being used. Overall water quality will be improved with the application of a DAF system near the intake. The system needs to be capable of treating at different depths that change based on the depth of the thermocline and the depth of the operating intake pipe. The system also needs to be accessible for maintenance, and must be suitable for operating in a recreational lake. Our goal is to make this system fully automated, as well as be sized in a way that enables it to remove the most suspended solids before going into the treatment plant. The picture below shows our team collecting raw lake water to use for testing.

TESTING & OUTCOMES

A DAF prototype was tested on 55 gallon barrels full of water containing algae. Based on the required amount of supersaturated water to float solids in each barrel, we determined the amount of air needed to float solids. The prototype DAF system pictured below can add 40 gallons per minute of supersaturated water and will add 14.21 grams per second of air into water.

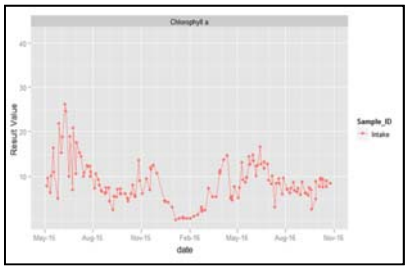
Based on the given flow rates we can find the time needed to treat any volume of water. To determine the required treatment depths, we analyzed thermocline data for summer months from BWD. The goal was to treat above the thermocline without breaking it to avoid excess nutrient exposure. We created an Excel spreadsheet to determine the treatment depth based on the thermocline depth, lake elevation, and intake used to find the treatment volume. More testing in Beaver Lake with a larger prototype DAF system will be conducted before the end of the semester to further prove that the system design works in an open water system.



The graph above shows the successful differences between Pre and Post-DAF testing.

SUSTAINABILITY

The graph below shows data from BWD of Chlorophyll-a from May 2015 to November 2016 in Beaver Lake at the intake.



This clearly shows that Chlorophyll-a levels are higher in the warmer months, therefore those are the times when algae production is the highest. Our project creates a very sustainable solution to one of Beaver Water District's biggest ongoing problems in their water treatment facility. Based on our testing and modeling, DAF technology will be able to significantly remove suspended solids and algae from the area around the intake pipes, which will reduce the amount of Chlorine needed to treat the water, therefore reducing the amount of Hypochlorous acid that is formed. This will decrease the amount of DBPs that form within the treatment facility, reducing maintenance and treatment costs for Beaver Water District. Ultimately, the cost of drinking water for the community of Northwest Arkansas could also decrease, making this solution not only environmentally sustainable, but also economically and socially sustainable. This project enabled our team to see positive potential effects not only for our client, but also for our local community and environment. Each phase of this project, from writing a technical report, scheduling professional meetings, or conducting lab tests, has been beneficial to our college experience as well as our futures as biological engineers. We would like to thank Dr. Scott Osborn, BWD, and the Biological and Agricultural Engineering Dept. for all of their support with our project.