PILOT TESTING FOR EFFECTIVE MEDIA SELECTION

ABSTRACT

With the likelihood of regulated contaminants expanding in the future, water utilities need a consistently reliable way to collect data, select the best filtration media, and maintain effective treatment. A well-run pilot study will ensure sound, data-driven decisions.

INTRODUCTION

In April 2024, the US Environmental Protection Agency (EPA) announced new limits for per- and polyfluoroalkyl substances (PFAS) in the nation's drinking water. The new ruling caps the maximum contaminent level (MCL) for perfluorooctanoic acid and perfluorooctane sulfonic acid at 4 ng/L, forcing utilities to prove that their treatment processes are creating safer water supplies and avoiding health concerns linked to these "forever chemicals."

According to the new EPA rules, once water systems have tested positive for PFAS levels above the MCL for three consecutive quarters, they are mandated to move into a design phase. The initial phase can include a mathematical model of the desorption and ion exchange (IX) media as well as laboratory scale testing using absorption isotherms and rapid small scale column testing (RSSCT). Mathematical modeling and laboratory testing have limitations in determining the effect of background water quality and seasonal water quality variations. A pilot study comparing several media types is the most effective way to determine the optimal media and get a general idea of operating costs associated with change out and disposal.

It's imperative that utilities understand what it takes to run an effective pilot program and recognize its benefits and challenges. It's also important to choose the best provider of water treatment media solutions—ones that are customized and data-driven to address a utility's specific needs.

PILOT STUDY PREPARATION

Key variables must be considered when preparing for a pilot study as they lay the groundwork for generating reliable data on long term costs associated with the media's two main factors that must mimic the full-scale operation are empty bed contact time (EBCT) and hydraulic loading rate (HLR).

EBCT. Pilot units should be operated at the same EBCT as the full-scale filtration system. These contact times will vary depending on the media selected, with IX resins operating as low as 2 minutes of EBCT and Granular Activated Carbon (GAC) at 10 minutes of EBCT per column. When using the data to design filtration equipment, it should always be done according to the media volume needed at the desired contact times rather than the pounds of media used.

This is especially important because on the carbon side, some domestic media can be 25% more dense and weigh 25% more. But the same volume of media can treat the same volume of water. If a system treats the same volume of water with the same media and it weighs 25% more and is purchased by the pound the treatment costs significantly more.

HLR. Along with the EBCT, the HLR should mimic the full-scale filtration system. The HLR is determined by dividing the flow rate by the surface area of the vessel. For instance, a 12-foot diameter vessel has a surface area of approximately 113 square feet. At a flow rate of 1,000 gpm, the HLR would be 8.84 gpm/ft^2. This is the maximum HLR that carbon can handle. On the other hand, IX media and surface-modified clay can handle HLR rates from 6 to 18 gpm/ft^2. This allows higher overall flow rates per vessel, resulting in a smaller filtration system footprint.

The pilot study must mimic the full-scale operation to generate reliable data. Problems could arise when stakeholders try to speed up the pilot process, limit- ing the time needed to fully understand the quality of the water in question. Shortcuts might be taken with shorter contact times or higher HLRs. The problem with either is that the shorter time frame may not scale up accurately to the larger filtration systems necessary for a full-scale operation.

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OPTIMIZING MEDIA

Although there aren't actual industry standards for best practices, there are different ways to conduct pilot studies, and each yields different results. Each method comes with its own economic and scientific opportunity cost.

The first method is the adsorption isotherm, which uses the water quality data from a sample collected from the site. This test is extremely difficult to conduct at the extremely low concentration levels associated with PFAS compounds. It doesn't give any information related to adsorption kinetics, a major controlling factor in PFAS remediation. The adsorption isotherm test requires the least time and money but also provides the smallest amount of data.

The second method is the RSSCT, in which water is gathered from the site and run through small-diameter columns with a reduced particle-size media. Although this test does provide more valuable information than an adsorption isotherm, the scale-up and ability to compare one medium with another are still in question. The RSSCT can be a nice mix of adequate time and enough data to make a decision.

The third method is a full-scale pilot test that involves installing mechanical filter devices at the site to run the water through for a given period until a contaminant breakthrough is achieved. Full-scale pilot tests are the most expensive and time-consuming but provide the most valuable data.

POTENTIAL BENEFITS

For municipalities and other water systems, pilot tests offer the following benefits:

Testing Multiple Media. Water systems can test multiple filtration media side by side while accounting for variations in water quality. Testing multiple media offers the chance to determine the best solution for a filtration system and determine long-term operational costs associated with media changeout and disposal.

Pivoting When Necessary. Piloting also gives utilities the data to pivot from a particular media. If a filtration system doesn't deliver the results needed, providers can point back to the state regulating department, move away from a particular medium, and choose another. For example, an agency might select a particular brand of IX and then discover it doesn't perform as well as initially expected. Another brand can then be selected on the basis of the pilot study results.

Envisioning Long-Term Water Quality. With any type of quick laboratory tests like the adsorption isotherm test or RSSCT, the samples are gathered from the water supply on the day of the test. Those samples give a snapshot of the water quality only at that moment. Water quality varies daily, so a snapshot on a given day doesn't provide a complete picture. The effects of changes in water quality from one week to the next go undetected. Because pilot studies run from four to six months, they provide a clearer picture of the actual water quality, including the changes over time and the effects of those changes.

Water systems that conduct pilot studies incur an additional up-front cost, but over time, they'll benefit from the customized solutions provided by the in-depth data these studies supply. Pilot testing allows for data-driven decisions in selecting the best media for unique water quality challenges.

SIX STEPS OF AN EFFECTIVE PILOT STUDY

An effective pilot study consists of six steps to test various filtration media in a controlled environment over time.

Step 1: Conduct a Water Analysis. An effective pilot study begins with a comprehensive water analysis to determine the specific PFAS contaminants in the water and any other background organics and inorganics that happen to be in the water. The water analysis is beneficial not only for the immediate need to address EPA's new requirements of MCLs for PFAS but for any contaminants that may become regulated in the future or may pose negative effects on the media.

Step 2: Feasibility Study. Following the initial analysis, it's important to run a feasibility study, considering the end user's required flow rate. The goal is to use the small-scale pilot test to mimic what the full-scale design will be. For example, if a municipality has 1,440 gpm, which would be 1 MGD, how would the treatment system be provided?

What would that look like given the filtration system size and contact time available in the media as well as the HLR? The goal is to mimic those requirements on a smaller scale within the pilot study.

Step 3: Select the Media. Following the feasibility study, the media can be selected according to the water analy- sis results—either the third-party tested results or those sent out in a water quality report. The results determine the appropriate filter media that can be selected to remove PFAS from the water effectively. A GAC, IX, or specialty media such as surface-modified clay may be selected depending on the understanding of the background water quality.

Mathematical modeling can be conducted using the water quality data for various media as a first step in media selection. Any media tested in a pilot unit should be supplied with a certificate of analysis from the manufacturer, which should be compared with a technical data sheet. The sample should be sent to a third-party laboratory to verify the certificate-of-analysis data.

Step 4: Conduct the Pilot Study. The pilot study uses columns ranging from 3 to 6 inches in diameter. The media is inserted into columns that are next to each other, with water running into each column. Regardless of the media selected, the pilot columns should operate with the surface loading rate and EBCT identical to what would be needed in a full-scale operation. The pilot runs for a period of four to six months until it achieves breakthrough of the PFAS compounds that were over their limit in the initial water testing phase.

Step 5: Determine Mechanical Design Parameters. The bed depth, backwash rates, and size of the vessel for the full- scale operation are determined according to site flow rates. Once the appropriate media is identified—GAC, an IX resin, or a specialty media—the flow rate and media selection will dictate the design of the filtration treatment mechanical system based on EBCT and hydraulic loading rates for that location.

Step 6: Conduct a Long-Term Cost

Analysis. Finally, with all the preceding information in place, a long-term cost analysis can be generated. This analysis is based on the breakthrough curves generated during the pilot study and will project the treatment operating costs in a full-scale operation. Determining the long-term costs up front allows water systems to assess their need, allocate resources, and take a proactive approach to putting treatment solutions in place.

PILOT TESTING CHALLENGES

Time and expense are by far the most prohibitive challenges to pilot testing. An investment of time and money is required to get the best data to select the best filtration media that addresses the most unique challenges. In fact, on the financial side, the total cost of a pilot study may be $25,000 to $125,000, depending on the number of media tested and analytical requirements, and the initial time investment may be up to a year.

The tradeoff for the end user comes in the value of the data resulting from the study, which, over time, can result in significantly lower operating costs because the solution provided can be customized according to the specific data at the specific location. Mathematical modeling can also be employed to help reduce some of the preliminary analytical costs. Solution providers can estimate when to start taking samples, for example, and how long to run the study. The initial investment is signifi- cant, but over time, the opportunity costs far outweigh the up-front expense.

FUTURE OUTLOOK

EPA regulates a fixed number of compounds, among them PFAS, arsenic, and perchlorate. Most experts agree that the number of regulated compounds will increase at some point. Similar to EPA's recent refining of the rule about MCLs for PFAS, as science reveals more about how water contaminants affect human well-being, the limits on concentrations of other pollutants may change. Water systems that conduct pilot studies will have the data they need ahead of any regulatory shifts.

Current testing provides lists of com- pounds, some of which EPA regulates and some it deems nonhazardous to health. Regardless, the end user has those data. If the regulations change, the water system already has the information needed to address the new limitations for water quality. So pilot testing results in safer water today and prepares utilities to continue providing safer water in the future.

Pilot testing yields data that contribute to cost-effective water treatment solutions. Although it comes with a price tag and a unique set of challenges, the benefits to utilities lie in the customized, data-driven solutions resulting from effective pilot studies. In the end, the benefits more than make up for the costs.