EVALUATION OF WATER TREATMENT PROCESSES THROUGH PILOT STUDIES

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INTRODUCTION

Currently the Environmental Protection Agency (EPA) is developing regulatory requirements for 86 compounds as a part of the Safe Drinking Act (SDWA) Amendments. Additionally, 25 new compounds will be regulated every three years and added to the existing list. More specifically, the SDWA Amendments require enhanced filtration and thorough disinfection of all surface waters.

With these new regulations, the EPA has defined treatment technologies which can be implemented to meet the regulations. These technologies include less common, and potentially very expensive, treatment techniques, such as ozone and granular activated carbon.

Faced with changing federal regulations, consumer demands for safe water, and potentially high costs, water suppliers need an effective way of determining acceptable treatment technologies for the least cost.

Pilot studies offer an economical method to test alternative and often innovative treatment technologies without affecting the existing process. The following describes the benefits of performing pilot studies and outlines a case study done in Charleston, South Carolina.

PILOT STUDY CONSIDERATIONS

Pilot studies are valuable in developing changes in an existing water treatment process to improve performance and/or reduce cost. This is particularly true when an alternative treatment process is considered. The advantages of pilot studies, which far outweigh the disadvantages, include the following:

- Experiments can be implemented without interruptions of the existing treatment process.
- Allows a plant to stay abreast of new technology (e.g., ozone and granular activated carbon).
- Experiments can be performed with alternative treatment processes not available at an existing facility.
- Eliminates the risk of exposing the consumer to contamination if a full-scale test should fail.
- Optimizes an existing water facility with the highest quality water at the lowest cost.
- A way to monitor bench-scale study results before implementing full-scale.
- An excellent tool to evaluate a treatment process if it is difficult or impossible to perform by jar testing.

The disadvantages of performing pilot studies, are that a pilot unit may be costly unless the expenditure is justified, however the majority of the cost is incurred in the design and construction of the pilot unit. Another disadvantage is that it may be difficult to find a proper location for the pilot unit such that a pilot study can be performed with maximum flexibility.

A pilot study can accommodate several objectives depending on the application. The four areas in water treatment that could justify the need for a pilot study include the following:

- The Technical Feasibility of a Process
- The Economic Feasibility of a Process
- Process Refinement
- A Cheaper Treatment Alternative

Once the type of pilot study has been determined, the test parameters must be defined to meet the stated objectives of the testing. The type of test parameters in a study fall into one of two categories: (1) those which can be evaluated by both jar testing and/or pilot testing, (i.e., chemical addition sequence, mixing intensity, water quality) and(2) those which are impossible to evaluate by jar testing due to the physical limits of the bench-scale equipment. Examples would be comparing filter media performance or evaluating the physical and chemical effects of ozone.

With the new SDWA regulations, the need for pilot studies will increase since the selection of a water treatment process will be much more stringent and may inherently be more risky if tested full-scale.

Pilot studies are often limited by time schedules; therefore, they may not be conducted over a year-round period. It is crucial that good judgement be used to anticipate the variation in water quality during the time that no studies are performed.

CASE STUDY

As an example of the use and benefit of piloting, the Charleston, S. C. Commissioners of Public Works (CPW) conducted a study at the 118 MGD Hanahan Water Treatment Plant which evaluated basic treatment concepts, alternative coagulants, filter media, and ozone.

The pilot plant was constructed on-site and consisted of identical (scaled-down) unit processes as the full-scale plant. The pilot plant included two identical trains each with a capacity of 7.5 gallons per minute, which were operated simultaneously to compare alternative treatment technologies. Rapid mix, flocculation, sedimentation, pre-filtration chemical addition, and filtration were included in each train. Also, the capability to add ozone prior to coagulation and prior to filtration was included. Six alternative filter media were installed in the pilot plant. A flow diagram of the two-train pilot system is shown in Figure 1.

The pilot study was preceded by a detailed jar testing program, which optimized basic treatment processes, such as mixing duration and intensity, point of chemical addition, and coagulation pH and dosages. Other processes, such as filtration and the use of ozone to aid coagulation, could not be evaluated in the jar testing. The use of the pilot plant in these areas is described in the following sections.

Filter Media

Six filter media designs were selected for evaluation in the pilot plant. These included (1) a dual media consisting of sand and anthracite taken from the full-scale plant, (2) a dual media consisting of an alternative sand and anthracite, (3) a dual media consisting of sand and granular activated carbon (GAC), (4) a tri-media consisting of sand, anthracite, and garnet, (5) a monomedia consisting of GAC, and (6) a monomedia consisting of an expanded bed depth of GAC.

The existing plant media was used as a basis on which to judge the performance of the other media. The pilot plant allowed comparison of six different media in side-by-side tests without interruption to the full-scale plant, at a fraction of the cost of installing alternative media designs in the full-scale filters, and in a shorter time-frame than what would be required to remove and replace the full-scale plant media. The pilot plant also allowed the comparison of innovative media designs including a tri-media design and a design which increased the media depth from the existing 30 inches to 42 inches. The configuration of the full-scale filters currently will not allow more than 30 inches of media due to backwash requirements.

During the initial runs of the pilot plant, one train was used to supply water to all six filters. The media designs were evaluated based on rate of headloss build-up, effluent turbidity and color, and the length of run.

Figure 2 is an example of comparing the rate of headloss build-up for the six media designs. Figure 2 shows that the sand/GAC media design had the lowest rate of headloss build-up. This is significant as long as the effluent turbidity remains acceptable, because a lower headloss will mean longer filter runs, more total water filtered in a given run, and overall less total backwash water used.

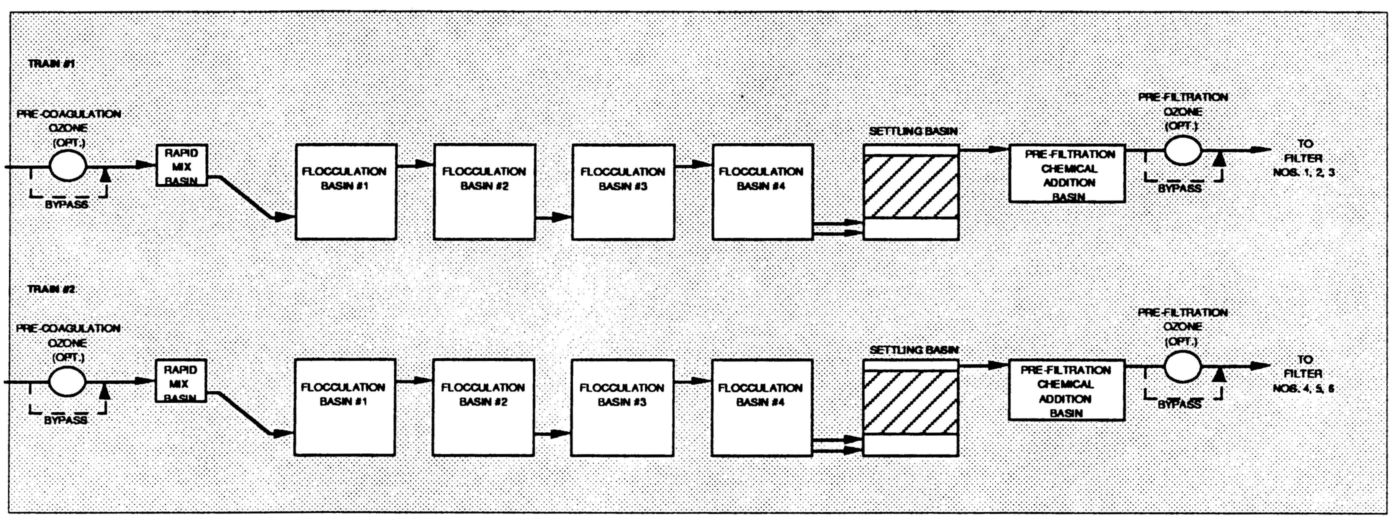
The results of the filter media pilot testing indicated that there were two promising alternative media designs. These consisted of an alternative sand/anthracite and a sand/GAC mixture. These two designs consistently produced better effluent turbidities and lower rates of headloss buildup.

To continue the pilot evaluation of the two best media designs, both trains were isolated and supplied water to three filters each for the remainder of the runs. The media was replaced so that each train included the sand/GAC, alternative sand/anthracite, and existing plant sand/anthracite media designs. The results of the additional testing confirmed that the sand/GAC media design performed best.

The pilot plant allowed comparison of alternative media designs without the possibility of contamination of the full-scale plant. Once the pilot plant confirmed the acceptability of these alternative media designs, a full-scale plant trial was initiated. The full-scale trial utilized two filters with existing plant media as a control, two filters were replaced with the alternate sand/anthracite media design and two filters were replaced with the sand/GAC media design.

The effluent color, turbidity, metals, organics, and bacteriological quality were monitored over a one month period. The results are now being evaluated to recommend a replacement for all of the filter media.

FIGURE 1. Hanahan Pilot Plant Flow Diagram



Ozone

The coagulation process was evaluated in the jar testing program by comparing alternatives to alum. Preliminary jar tests indicated that ferric chloride produced a high quality water with lower color and total organic carbon (TOC) than alum. Coagulant aid polymers were shown to be effective in reducing the amount of primary coagulant required. The use of ozone was also anticipated as being effective in reducing the amount of primary coagulant required for certain types of waters. However, testing ozone in a bench-scale (jar tests) study was not possible. The pilot plant enabled side-by-side comparisons of alum, ferric chloride, and coagulant aids, as well as ozone.

The results confirmed that ferric chloride was effective in treating the water and justified performing a full-scale plant trial. The coagulant aids were also shown to be effective in reducing the amount of primary coagulant required and justified including these in the full-scale plant.

However, the use of ozone did not reduce the amount of primary coagulant required to effectively treat the water. Ozone would reduce the raw water color by up to 50%, but typically the raw water turbidity would increase. The treatment process was hindered by the use of pre-coagulation ozone. Unsettled floc particles would typically carry-over from the sedimentation basins and cause a high color and turbidity load being applied to the filters resulting in shorter runs.

To test ozone in the full-scale plant would have cost millions of dollars. The pilot plant allowed testing for a few thousand dollars. The results confirmed that ozone was not effective and that it should not be considered for use in the full-scale plant.

Conclusion

As a result of the Hanahan pilot study, significant expenditures, expected to be made, have been eliminated or delayed. Additionally, the "Master Plan" approach allowed the complete evaluation of all treatment process variables and has justified the option to switch to an alternative, high quality water supply. Basic plant modifications have also been made which have improved water quality and lowered costs. Finally, as regulations change, new treatment concepts can be implemented to assure regulatory compliance and continued public confidence.

FIGURE 2. Hanahan Pilot Plant Run #6 Headloss Decay Curve