Tech Brief

PUBLISHED BY THE NATIONAL ENVIRONMENTAL SERVICES CENTER

Turbidity Control

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Summary

One of the water treatment operator's primary jobs is controlling turbidity. Turbidity control is usually associated with surface water systems and groundwater systems under the direct influence of surface water. This *Tech Brief* examines turbidity control through the entire water treatment process from the raw water source to the clear well.

What is turbidity?

Turbidity is caused by particulates in the water and is synonymous with cloudiness. Measured in NTUs [nephelometric turbidity units] or occasionally in JTUs [Jackson turbidity units], it is significant because excessive turbidity can allow pathogens to "hide" and, hence, be resistant to disinfection. (For more information about turbidity, see the article "Optimization: Helping Small Water Plants Improve Their Product" in the Winter 2005 *On Tap*.)

The various supplemental articles mentioned in this Tech Brief are available on the National Environmental Services Center Web site at *www.nesc.wvu.edu/ndwc*.

Source Water and Watershed Protection

Turbidity control can and should start with the source water and the area around that source. Owning or having control of the land in the watershed area of your source water can make a tremendous difference in the source water's quality. Controlling land use for the purposes of lessening contaminants, and especially soil erosion and sedimentation control, is becoming more important as populations increase. Water systems should work *with* local watershed groups, farmers, developers, Natural Resource Conservation Service offices, local extension offices, county commissions, and state environmental departments on water issues. The message they need to convey is better the source water, the easier and less expensive treatment will be. Turbidity reduction or control at the source is a cost effective and efficient way to eliminate multiple levels of treatment.

Raw Water Intake

The key to turbidity control is having a good awareness of your intake and the quality of the source water. There are measures that an operator can adopt to help minimize the intake of turbid or dirty water. Most intakes have a screen or a structure of some kind to hold back debris. These screens or areas can become silted in with dirt and must be cleaned. If your system does not have a screen on the intake, install one as soon as possible.

Some raw water pumps can be reversed to flow the water back out to flush the immediate area around the intake. Never do this at the beginning of the shift or the beginning of the production day. The flushing should be done at the end of the day before shutting down if your plant does not produce water 24 hours a day. If the plant operates continuously, then the flushing should be at the time of lowest demand so that the can water clear up.

The time it takes for the water to clear following the flush depends on the velocity of the water that carries the silt downstream.

The faster the water flows in the river, the less time it should take to clear up. If a reservoir is your source water, it may take several hours. If the pumps do not have the capability to reverse or there is not enough water to push back through the intake, the cleaning must be done manually using an excavator and a vacuum truck (and possibly even a diver). The cleaning intervals vary from once a year to once a decade, depending on how clean the source water is. Visual inspections may need to be done with a camera or diver. Don't forget to turn off the raw water pumps when inspecting.

The operator should record the raw water turbidity every day that he or she produces water, even if it is not a state requirement. Sampling the raw water should be done upstream from the intake. Even though the intake might be a long distance away from the plant, it is useful to see the difference between source water turbidity and the turbidity prior to treatment. Record data related to different operating scenarios, weather conditions, and other incidences that increase or decrease turbidity in the water.

If the plant does not operate continuously and can shut down temporarily, a good practice is to produce water before any rain storms when the water is the cleanest. Some plants can't handle extremely turbid water. Watching or listening to the weather forecast can be helpful in controlling turbidity.

Another good practice for operators is to keep in daily contact with other water system or sewer system personnel up and downstream from your plant. Things like flash floods or problems with industries or sewage plants are easier to deal with if you know about the problem before it gets to your intake. The operator can make as much water as possible before shutting down and letting the problem pass. Don't forget to relay the information downstream to other water systems. (For more information about networks, see the article "Crisis Communication: Building a Network to Keep Drinking Water Safe" in the Fall 2002 *On Tap*.)

Coagulation, Chemical Feeds, Flash Mix

Turbidity reduction is best achieved when the water is run through a series of chemical and physical treatment methods before reaching the filter. The terms coagulation, flocculation, and flash mix are often discussed together. Basically, coagulation is the process of getting particulates to stick together, flocculation is when this process becomes visible, and the flash mix is the fast mixing that makes it happen.

Coagulants include alum or polyelectrolytes such as polyaluminum chloride. Some water will react better with one chemical than the other. The correct dosage is determined with jar testing and feed pump calibration. (For more information about jar testing, see the Tech Brief on this subject in the Spring 2005 *On Tap*.) The coagulant is usually injected into the line before the flash mix, sometimes using a static mixer (a short piece of pipe with internal spiral fins). If your plant is not equipped with an in-line static mixer, it would be a fairly inexpensive investment and an improvement to the treatment process.

Proper mixing is important to coagulation, as is the proper dosage of the coagulant. Coagulation can start as soon as the chemical is added, but the flash mix kicks the process into high gear. The flash mix is usually aided with a motorized paddle or the water is allowed to fall (splash) into a chamber making the water turbulent. Although it isn't required, the operator can take a daily turbidity reading at the end of the flash mix.

Flocculation

Flocculation usually consists of a two-or three-stage process, and begins when the particulates start sticking together more visibly. The process still uses the motorized paddles, but at a slower rate than during the flash mix. Stage one of flocculation is fastest, with the second and third stages working more slowly and sometimes with the paddles moving in the opposite direction. In some plants, it is possible to adjust the speed of these motors. Keep in mind you want the last stage to be at a slow, consistent speed so as not to break up the particles. This allows the particles to get heavier and helpd them settle to the bottom in the next part of the process, sedimentation. Again, it would not be a bad idea to take daily turbidity readings at the end of the flocculation process.

Sedimentation

During sedimentation, the particles of dirt settle to the bottom of the basin. The sedimentation basin is the last step before the filters, so sedimentation must work effectively. The key to good sedimentation is having enough area and/or time for settlement and, subsequently, good sludge removal.

Table I

Summary of Optimization Monitoring and Performance Goals

Minimum Data Monitoring Requirements

- Daily raw water turbidity
- Settled water turbidity at four-hour time increments from each sedimentation basin
- On-line (continuous) turbidity from each filter
- One filter backwash profile each month from each filter

Individual Sedimentation Basin Performance Goals

- Settled water turbidity less than 2 NTU 95 percent of the time if raw water turbidity is greater than 10 NTU, or
- Settled water turbidity less than 1 NTU 95 percent of the time if raw water turbidity is less than or equal to 10 NTU

Individual Filter Performance Goals

- Filtered water turbidity less than 0.10 NTU 95 percent of the time (excluding
  15-minute period following backwashes) based on the maximum values recorded during four-hour time increments
- Maximum filtered water measurement of 0.30 NTU
- Initiate filter backwash immediately after turbidity breakthrough has been observed and before effluent turbidity exceeds 0.10 NTU
- Maximum filtered water turbidity following backwash of 0.30 NTU
- Maximum backwash recovery period of 15 minutes (i.e., return to less than 0.10 NTU)
- Maximum filtered water measurement of less than 10 particles (in the greater than 2 micron range) per milliliter (if particle counters are available)

Disinfection Performance Criteria

- CT values to achieve required log inactivation of Giardia and viruses

Sludge at the bottom of the tank is usually scraped with a slow-moving blade to a sump and drain. Some settlement basins have a cone-shaped bottom to direct the sludge to a drain. It still may be necessary to drain the sedimentation basin and clean the sludge every five to 10 years, depending on the water quality. Some sedimentation basins have tube settlers (slanted tubes that help with contact area and time for settling). Sometimes baffling is used or can be added to help the sedimentation time.

At the end of the sedimentation period in each basin, record settled water turbidity at four-hour time increments. This practice helps judge the performance of the sedimentation basin(s). It is important for the sedimentation basin(s) to operate optimally so the filters do not get overworked and to make sure the filters can handle the incoming turbidity with no bleed-through of dirty water. Individual sedimentation basin performance goals are shown in Table 1 XXX.

Filtration

Filtration is the last stage in turbidity control before the clear well. Most filters can handle a wide range of turbidity, but don't leave all the work up to them. The other processes—chemical mix, flash mix, coagulation, flocculation, and sedimentation—must work optimally for the life of the filters and to provide a safety factor or cushion for lower turbidities. The less turbidity going into the filters means longer filter runs and longer filter-media life, which saves money. Individual filter performance goals are show in Table One.

The minimum data monitoring requirements for the filters are:

- On-line computer recorded (continuous when in operation) turbidity from each filter. If the water system only has two filters, the combined filter effluent can be monitored but it is recommended that each filter has individual monitoring.
- One filter backwash profile should be done each month from each filter. This is where the turbidity versus time is plotted on a graph when backwashing.

Some of the information above is mandated through each state's regulatory agency, which is derived from the Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR) and/or the Interim Enhanced Surface Water Treatment Rule IESWTR). (For more information about the LT1ESWTR and the IESWTR, see the Q&A in the Spring 2004 *On Tap*.)

Continuous turbidity monitoring equipment needs to be cleaned and calibrated on a regular basis. Check with the manufacturer to get maintenance and calibration schedules for turbidity equipment. You may have to order supplies for cleaning and calibration procedure ahead of time. Be advised that some if not all of the calibration standards have a shelf life.

Inspect the filter media at least every quarter. A few things an operator can do to inspect the filter on a regular basis include:

- Measure each filter bed thickness in at least six places spaced evenly in the filter bed. This will show any losses of filter media over time and an uneven media bed. Add media as necessary.

- As the filter goes into backwash, watch for uneven bed expansion at the beginning of the backwash. This could be a sign of a clogged diffuser or broken under-drain tile. This could also be the cause of the uneven media bed thickness.
- Measure the backwash rate and filter bed expansion.
- When the filter bed is fully fluidized, take a sample of the filter media and visually inspect the media after air drying. Then, take a portion and acid wash it and let it air dry. Look for structural break-down of the media and/or mineral deposits.

The viability of the media is very important for efficient operation of the filtering process. (For more information about filter backwashing, see the *Tech Brief* on this subject in the Fall 2005 *On Tap*.)

Clear Well

The clear well can, over a long period of time, accumulate sediment. The clear well should be inspected at the same time as the storage tanks are in the distribution system and be cleaned as necessary. A couple of things can be done to keep any sediment that may be in the bottom of the clear well from stirring up.

- Don't let the water splash into the clear well. Use baffling, a splash pan or other means to flow the filtered water in slowly.
- Try not to empty the clear well during normal use. If there is sediment in the clear well, it might get stirred up and end up in the distribution system.

Distribution System

Sediment can accumulate in the distribution system over time and when a line break occurs or a fire hydrant is opened, it will get stirred up. Several things can be done to control this problem in the distribution system. (For more information about water quality in distribution systems, see the *Tech Brief* in the Fall 2002 On Tap.)

- Flush the system twice a year, working out in a radial pattern from the treatment plant will keep accumulated sediment out of the lines. This flushing should be done at low-use times to allow the water to settle and reduce any complaint calls from customers. Also, don't flush during cold weather when ice problems could be created on roads and streets or cause the fire hydrant to ice up making it difficult to close. Keep track of this water for the water accountability report as water used for maintenance.
- Inspect storage tanks regularly and clean sediment as necessary to help prevent customer complaints.
- Isolate line breaks and flush that section before opening the rest of the system.
- Line pigging or swabbing is a procedure to swab the distribution lines out and clean them. This is usually done right after a new line is constructed but can also be done on existing lines.

By following the procedures outlined in this *Tech Brief*, operators can lower turbidity in the water during all stages of the treatment process. Lower turbidity means lower treatment costs and better quality drinking water.

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Published by The National Environmental Services Center at West Virginia University, P.O. Box 6064, Morgantown, WV 26506-6064