Evaluation of Particle Counting as a Measure of Treatment Plant Performance [Project #505]

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BACKGROUND
Particle counters are instruments that both count and size particles. In the future, particle counting could play a big part in drinking water treatment. Integrated on-line particle counting systems could continuously categorize source water, water at various stages of treatment, and fully treated drinking water and provide the information needed for process control decisions. The primary objective of this study was to enhance and expand the understanding of particle counting analysis in drinking water treatment applications.

There are three ways in which samples can be analyzed for particle counts and particle size: individual sample analysis (discrete sample analysis), on-line sample analysis (real-time flow monitoring), and batch/on-line sample analysis (volumetric on-line mode). The basic components of a particle counter are the sensor and the counter (data processing device). For discrete sample analysis, a sampling device (batch sampler) is also necessary. For on-line sample analysis, a flow controlling device is required. Sensors operate using light obscuration, light scatter, or electrical resistance principles.

APPROACH
A list of instrument performance criteria relevant to drinking water applications was developed. Using the defined criteria, an instrument evaluation data sheet was prepared and used to evaluate six commercially available particle counters for applicability to drinking water treatment. Procedures used for performing the instrument evaluations are presented in detail. With the exception of experiments whose design required a reference instrument, these experiments to assess instrument performance can be conducted in any well-equipped laboratory. The reference instrument used in these studies was a flow cytometer.

In this study, quality assurance plans and quality control protocols were developed specifically for particle counting and sizing. It is important to count enough particles to enable statistical manipulation of the data. The general approach used in this study was to count a minimum of 100 particles in the size range(s) of interest and to make full use of all available instrument channels. Samples were analyzed in triplicate. The first analysis was considered an instrument rinse and results were not used. The average of the second and third replicates was reported.

RESULTS
Discrete and on-line particle counting modes were compared during a stable period of filter operations as well as during the filter ripening phase immediately following a backwash. There was no significant difference between results obtained by discrete and on-line monitoring when sampling frequencies were identical. Most of the advantages of discrete sample particle counting relate to the flexibility afforded by collection of an actual sample. On-line particle counting provides a real-time picture of particulates in a process stream. Many more samples can be processed by automated on-line particle counting than would be practical with discrete sample analysis.
In order to get meaningful results when selecting a sensor, particle concentration range, particle size detection limit, sample flow through the sensor, resolution, pressure requirements, and sensor orifice size must be carefully considered. Generally, a sensor with a high size detection limit and high concentration limit would be suitable for monitoring the filter ripening phase. The use of submicron size ranges to monitor filter effluent quality during periods of stable filter operation provides higher counts and greater detection sensitivity. Particle count and size distribution analysis presented an informative picture of filtered water quality, produced both during the filter ripening phase and during periods of stable filter operation.

The value of particle counting as a surrogate measure for Giardia removal was also investigated. Various particle counters categorized the mode of the G. muris cyst population from 2.0 to 8.0 mm. These results demonstrate that the method of measurement affects the apparent size of G. muris cysts. More information regarding actual G. muris as well as G. muris-sized particles was gained in this study by monitoring particle sizes much smaller than the traditional 9.0-15 mm size range. If the intended use of particle counting data is as a surrogate for evaluation of Giardia cysts or Cryptosporidium oocysts, the instrument operator must ensure that the size channels selected for analysis have been optimized for detection of these organisms.

In the applications summarized here, total cumulative particle counts greater than or equal to the lowest size range monitored, differential particle counts, particle size distribution in terms of percentage of total cumulative number of particles, and the power law slope coefficient all proved valuable measures of filtered water quality.