

treatment requirements to certain plants that maintain finished water turbidity at levels significantly lower than currently required. EPA is proposing to award an additional 0.5 log *Cryptosporidium* treatment credit to conventional and direct filtration plants that demonstrate a turbidity level in the combined filter effluent (CFE) less than or equal to 0.15 NTU in at least 95 percent of the measurements taken each month. Compliance with this criterion must be based on measurements of the CFE every four hours (or more frequently) that the system serves water to the public. This credit is not available to membrane, bag/cartridge, slow sand, or DE plants, due to the lack of documented correlation between effluent turbidity and *Cryptosporidium* removal in these processes.

b. *How was this proposal developed?* Turbidity is an optical property measured from the amount of light scattered by suspended particles in a solution. It is a method defined parameter that can detect the presence of a wide variety of particles in water (e.g., clay, silt, mineral particles, organic

and inorganic matter, and microorganisms), but it cannot provide specific information on particle type, number, or size. Turbidity is used as an indicator of raw and finished water quality and treatment performance. Turbidity spikes in filtered water indicate a potential for breakthrough of pathogens.

Under the IESWTR and LT1ESWTR, combined filter effluent turbidity in conventional and direct filtration plants must be less than or equal to 0.3 NTU in 95% of samples taken each month and must never exceed 1 NTU. These plants are also required to conduct continuous monitoring of turbidity for each individual filter, and provide an exceptions report to the State when certain criteria for individual filter effluent turbidity are exceeded (described in 63 FR 69487, December 16, 1998) (USEPA 1998a).

The Stage 2 M-DBP Advisory Committee recommended that systems receive an additional 0.5 log *Cryptosporidium* removal credit for maintaining 95th percentile combined filter effluent turbidity below 0.15 NTU,

which is one half of the current required level of 0.3 NTU. In considering the technical basis to support this recommendation, EPA has reviewed studies that evaluated the efficiency of granular media filtration in removing *Cryptosporidium* when operating at different effluent turbidity levels.

For the IESWTR, EPA estimated that plants would target filter effluent turbidity in the range of 0.2 NTU in order to ensure compliance with a turbidity standard of 0.3 NTU. Similarly, EPA has estimated that plants relying on meeting a turbidity standard of 0.15 NTU in 95% of samples will consistently operate below 0.1 NTU in order to ensure compliance. Consequently, to assess the impact of compliance with the lower finished water turbidity standard, EPA compared *Cryptosporidium* removal efficiency when effluent turbidity is below 0.1 NTU with removal efficiency when effluent turbidity is in the range of 0.1 to 0.2 NTU. Results from applicable studies are summarized in Table IV-15 and are discussed in the following paragraphs.

TABLE IV-15.—STUDIES OF *Cryptosporidium* REMOVAL AT DIFFERENT EFFLUENT TURBIDITY LEVELS

Microorganism	Average of log removals	Filtered effluent turbidity	Experiment design	Researcher
<i>Cryptosporidium</i> .....	4.39	≤0.1 NTU .....	Pilot-scale .....	Patania et al. (1995).
<i>Giardia</i> .....	3.55	>0.1 and ≤0.2 NTU		
<i>Cryptosporidium</i> .....	4.23	≤0.1 NTU		
<i>Cryptosporidium</i> .....	3.22	>0.1 and ≤0.2 NTU	Bench-scale .....	Emelko et al. (1999).
<i>Cryptosporidium</i> .....	4.09	≤0.1 NTU .....		
<i>Cryptosporidium</i> .....	3.58	>0.1 and ≤0.2 NTU	Pilot-scale .....	Dugan et al. (2001).
<i>Cryptosporidium</i> .....	3.76	≤0.1 NTU		
<i>Cryptosporidium</i> .....	2.56	>0.1 and ≤0.2 NTU		

Patania *et al.* (1995) conducted pilot-scale studies at four locations to evaluate the removal of seeded *Cryptosporidium* and *Giardia*, turbidity, and particles. Treatment processes, coagulants, and coagulant doses differed among the four locations. Samples of filter effluent were taken at times of stable operation and filter maturation. Analysis of summary data from the seeded runs at all locations shows that average *Cryptosporidium* removal was greater by more than 0.5 log when effluent turbidity was less than 0.1 NTU, in comparison to removal with effluent turbidity in the range 0.1 to 0.2 NTU (see Table IV-15).

Emelko *et al.* (1999) used a bench scale dual media filter to study *Cryptosporidium* removal during both optimal and challenged operating conditions. Water containing a suspension of kaolinite (clay) was spiked with oocysts, coagulated in-line

with alum, and filtered. Oocyst removal was evaluated during stable operation when effluent turbidity was below 0.1 NTU. Removal was also measured after a hydraulic surge that caused process upset, and with coagulant addition terminated. These later two conditions resulted in effluent turbidities greater than 0.1 NTU and decreased removal of *Cryptosporidium*. As shown in Table IV-15, average removal of *Cryptosporidium* during periods with effluent turbidity below 0.1 NTU was approximately 0.5 log greater than when effluent turbidity was between 0.1 to 0.2 NTU.

Dugan *et al.* (2001) evaluated *Cryptosporidium* removal in a pilot scale conventional treatment plant. Sixteen filtration runs seeded with *Cryptosporidium* were conducted at different raw water turbidities and coagulation conditions. Eleven of the runs had an effluent turbidity below 0.1

NTU, and five runs had effluent turbidity between 0.1 and 0.2 NTU. For runs where the calculated *Cryptosporidium* removal was concentration limited (*i.e.*, effluent values were non-detect), the method detection limit was used to calculate the values shown in Table IV-15. Using this conservative estimate, average *Cryptosporidium* removal with effluent turbidity below 0.1 NTU exceeded by more than 1 log the average removal observed with effluent turbidity between 0.1 to 0.2 NTU.

In summary, these three studies all support today's proposal in showing that plants consistently operating below 0.1 NTU can achieve an additional 0.5 log or greater removal of *Cryptosporidium* than when operating between 0.1 and 0.2 NTU. Because EPA expects plants relying on compliance with a 0.15 NTU standard will consistently operate below 0.1 NTU, the