A Guideline for UV Disinfection Against *Cryptosporidium* in Japan

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ABSTRACT

On April 1, 2007, the Ministry of Welfare, Health and Labor (WHL) in Japan enforced a guideline for ultraviolet (UV) disinfection at water treatment facilities. This is the first guideline in Japan to specify UV as an authorized disinfection method for drinking water treatment.

BACKGROUND

The outbreak of Cryptosporidiosis has been occasionally reported in Japan, and the severest one happened in Ogose City, Saitama prefect in 1996 with more than 8800 patients. After the huge outbreak due to the contamination of *Cryptosporidium* in the tap water supplied by the municipal water treatment system, the Ministry of WHL in Japan first launched an emergency countermeasure in 1996 by enforcing a tentative guideline for water treatment facilities specifying measures against *Cryptosporidium*. Subsequently in 2000, a ministerial ordinance was enforced to provide a guideline requiring filtration system to be installed at all water treatment facilities under a high potential risk of contamination with chlorine-resistant microbes such as *Cryptosporidium*. The guideline further specified that utilities were at the high risk of contamination if the source water was positive with indicator bacteria including Escherichia coli and anaerobic spores.In spite of the epoch-making outbreaks and sporadic cases of cryptosporidiosis, only about half of the corresponding utilities were found to be fulfilling the requirements. According to the data in March 2006, 6045 water treatment facilities, among 21609 facilities in total in Japan, were judged at the high potential risk of contamination with *Cryptosporidium* while only 3,368 utilities out of the 6,045 had installed filtration systems at the time. The fewer fulfillments were suspected mostly attributable to the initial and/or running cost of filtration systems because about 80% of the offending utilities were small scaled.

Meanwhile, many reports have indicated that UV disinfection is very effective against *Cryptosporidium* and particularly cost-effective with small-scaled water treatment systems. Based on the scientific outcomes, the Ministry of WHL in Japan has proposed and enforced the amendment for "Guideline for measures against *Cryptosporidium* in Japan" in March 2007, specifying UV exposure as an authorized disinfection method against *Cryptosporidium* at certain cases.

ESSENCE OF THE GUIDELINE

The guideline categorizes water treatment facilities into four level groups based on the potential risk of contamination with *Cryptosporidium*. The definition of each level and corresponding requirements are shown in Table 1.

Table 1. Definition of categories and corresponding requirements

Indicators* in source water	Source water property	Category	Requirements
Positive	Surface water	Level 4	Filtration
	Groundwater	Level 3	Filtration or UV Treatment
Negative	Surface water	Level 2	Monitoring source water at least once every 3 months
	Groundwater	Level 1	Monitoring source water once a year

* Indicators include Escherichia coli and anaerobic spores. Positive with either indicator is considered positive.

Briefly, the definition of categories and corresponding requirements can be summarized as follows:

If indicators are detected from the source water of a water treatment utility, the utility should (1) facilitate filtration system if the source is surface water [Level 4], or (2) facilitate either filtration or UV treatment system if the source is not surface water, i.e. groundwater. [Level 3]. UV treatment is not allowed at Level 4 utilities because surface water has many risk factors including high fluctuation with turbidity and high vulnerability to accidents in the watershed. Those risk factors are supposed to be managed 'more reasonably' with filtration than with UV, according to the guideline. If indicators are negative with the source water, the risk of contamination is considered rather low and no special apparatus against *Cryptosporidium* is required to be installed [Levels 1 and 2].

Table 2 shows the summary of performance requirements for filtration and UV treatment systems. The requirement for filtration is rather simple and defined with the turbidity of the filtrates. Meanwhile, the requirements for UV system specifies four issues including (1) minimum UV fluence, (2) target water properties of turbidity, color and UV transmittance, (3) UV intensity monitoring, and (4) turbidity monitoring. The apparatus design is also mentioned in the guideline to provide proper lamp arrangements and uniform hydraulic properties to constantly achieve the designed performance. The UV systems should completely stop the operation when the turbidity of source water exceeds 2 degrees, which is not the case if the filtration precedes UV exposure in the system. The guideline further stresses the importance of proper maintenance in all water treatment facilities as general requirements.

Table 2. Performance requirements

Apparatus	Requirements
Filtration	Turbidity of the filtrates shouldnot exceed 0.1 degree.[1]
UV treatment	(1) The UV apparatus should guarantee the minimum UV fluence of 10 mJ/cm^2 to be delivered to the 95% or more of water volume passing through the system. (2) The target water should meet requirements for three parameters including the turbidity not more than 2 degrees,[1] the color unit must not more than 5 degree,[2] and the UV transmittance at 253.7 nm must not less than 75%.[3] (3) A UV radiometer should be equipped to perform continuous fulltime monitoring of UV intensity in the system. (4) A turbidity meter should be installed for the fulltime monitoring of source water

[1] One degree of the turbidity corresponds to the turbidity of kaolin solution at 1 mg/L.
[2] One degree of the color unit corresponds to the color unit of the solution containing 1 mg/L of chloroplatinate potassium and 0.5 mg/L of cobalt chloride (hexahydrate).
[3] The required UV transmittance is equivalent to the UV absorbance of less than 0.125 for a 10 mm path length.

REMARKS

The guideline authorizes UV as one of the effective measures against *Cryptosporidium* at water treatment facilities using groundwater as the single water source. In other words, it defines filtration as the only one promising method against *Cryptosporidium* if the system fully or partially takes surface water as the source, which could be a controversial issue in the near future.

It should be noted that the guideline is subordinate to The Waterworks Law in Japan requiring the minimum residual free-chlorine of 0.1 mg/L at the tap. Accordingly, the finished water should anyway be chlorinated before being distributed, regardless of the UV application. The minimum fluence requirement of 10 mJ/cm^2 may appear 0low compared to other guidelines, which is simply because the chlorination is a mandatory in Japan and UV is therefore an additional measure specifically targeting *Cryptosporidium*. Expanding UV application to disinfect other microorganisms would surely need higher UV fluences, which could therefore lead to future amendments of the guideline.

The guideline defines the minimum fluence requirement for the certain amount of water, i.e. 95% of total volume. Such a volume-based definition of minimum requirement is a notable concept among UV standards and guidelines in many countries.

Another issue to be discussed is how to measure the UV fluence which is not well specified in the guideline. A biodosimeter using a certain microorganism appears one of the most possible methods to be adopted, just as defined in the Austrian standard. The specification of fluence measurement is currently under active discussion in Japan.

The enforcement of the UV guideline is just a small step but certainly opened up a new world in Japan. It is definitely needed to watch what happens with UV disinfection in the very near future.

Notes: This article is written at authors' own responsibility and is not officially endorsed by the Ministry of Welfare, Health and Labor in Japan. Accordingly, the terminology may differ when the Ministry announces the official English translation of the guideline.