Testing for Reliable Bacteria Reduction

Hand-held individual water purifiers (IWPs) are commercially available and have been used by the military since World War II. Because of variations in water quality and assumed usage patterns, and because of the lack of accepted testing standards, manufacturer performance claims have sometimes proven to be unreliable indicators of device effectiveness.

By Nikki Beetsch

Protocol developed for individual water purifier performance claims

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) received a grant from the Army Study Program Management Office to develop a protocol for products with such claims, NSF Protocol P248, Emergency Military Operations Microbiological Water Purifiers. USACHPPM received assistance from NSF Intl. and from many other DOD organizations. The protocol was derived primarily from publications of the U.S. Environmental Protection Agency (EPA) and NSF Intl.

Using surrogates, the requirements under the protocol are a 6-log reduction of bacteria; 4 log for virus; and 3 log for cysts. Because it is impractical to test with a continuous concentration for all organisms for the full test volume, performance is evaluated at microbiological challenge points during the test capacity. The protocol requires greater concentrations of bacteria than would be anticipated in source waters because these concentrations are necessary to determine the required log reductions. To represent field use, a bacterial "background" concentration for use between sampling events that more closely represents natural water conditions was developed.

The protocol applies to "natural water," defined as any body of water, standing or flowing, which is sufficient for a service member to use as a personal water supply. Available data, primarily derived from public water sources such as lakes, large rivers and reservoirs; recreational waters; and wadeable streams was reviewed to determine the bacterial quality of natural waters.

The intent was to determine conditions under which an IWP must operate. The sources for this research include a number of scientific journals, the EPA, the U.S. Geological Survey, the European Environment Agency, United Nations Environment Programme-Global Environment Monitoring System Water Programme and the World Health Organization (WHO). Source water standards exist in reference to recreational water safety and agricultural/fishery health impact. The EPA, EU Environment Programme and the WHO recommend maximum concentrations as shown in Table 1.

The comparison of the relative bacterial qualities of waters in different locations is based on the detection of indicator organisms. Total and fecal coliform are the most commonly used indicator organisms; they are the ones stated in regulations for water use classification (Table 1); and they provide an estimate of the pathogenic bacteria present in natural waters. Limited research was conducted to determine

Table 1. Recreational and Agricultural Standards (cfu/100mL)

Regulatory Agency	Total Coliform	Fecal Coliform	*E. Coli*	Fecal Strep	Enterococci	Note
EPA		*200/400	126		33/35 (Fresh/Marine)	*Previously accepted standards. *Enterococci* and *E. coli* are now used as indicator organisms.
U.S. States Class A	100-2400	14-200	18-130		14-100	Classes are defined by each state. Generally, class A reflects excellent quality for use such as shellfishing.
U.S. States Class C	2400	200-1000	142			Class C reflects Fair or minimal contact recreational use.
EU Imperative	10,000	2000				
EU Guideline		100		100		
WHO				40		This guideline represents the 95% level, below which less than 1 illness per 100 is probable.

Table 2. Literature review of EPA, USGS, international environmental agencies and educational institutions studies. Units are cfu/100mL unless otherwise noted.

Location	Sample Date	Water Source	Total Coliform	*E. Coli*	Fecal Coliform
Kansas	1998-01	Flowing	105-43,900	360	1,400
Wyoming[3]	1990-99	Flowing			1-45,000
Massachusetts	2004	Flowing		1-2,900	
Sierra-Nevada	2004	Mixed	600-10,000		
Canyon Lake, CA[4]	2002	Standing	8,500[a]	1-15[a]	1,000[a]
Seoul, South Korea	2002	Running	228	0-10	
Brazil	2001-02	Standing	3,200-40,000		
New Zealand					1,000
Germany[5]	2006	Standing		4.7-5,300	3-1,500
Epi Review	1950-Present	Standing	45-5,750	2-5,200	2-2,000
Benton, AK	1969-84	Mixed	0-35,000	1-2,100	0-50,000
Rio Grande[6]	2005	Running	27,000-95,000[a]		11,000-33,000[a]
Myponga Reservoir, Australia[7]	2003	Mixed		15-23,000	9-10,000
Rio San Juan, Mexico[8]	1995-96	Flowing	332,000[b]		111,000[b]
Epi study by Kay *et al*	1994	Standing			158 Strep
Grand River, Canada[9]	2002	Flowing	300-35,000	300-27,000	500-33,000

a Mean values
b Values may be per L vice per 100 mL, notation in journal unclear

Table 3. Summary results of the Information Collection Rule Auxiliary Database 1, for the presence of selected organisms in raw source waters, 1997-1998.

Organism	Min	Max	Mean	Median	Total Records	Non-detects
Giardia Cysts/100L	0.2	2,521	139	52	6,941	5,818
Crypto Cysts/100L	0.1	1,923	95	30	6,941	6,530
Total Coliform/100mL	1	500,000	1,037	4	9,636	4,287
Fecal Coliform/100mL	1	90,000	277	18	7,496	4,979
E. Coli/100mL	1	242,000	375	16	4,453	2,112
Virus/100L	0.1	1,974	16	2	4,207	3,332

Data represent results from U.S. states and territories. Summary values are for detections only. Non-detects are not averaged as zero values.

the ranges of total and fecal coliform concentrations in natural waters worldwide indicated (tables 2, 3) that total coliform bacteria detected ranged from non-detect to 500,000 cfu/100mL. From this information, a background concentration of 1,000 to 10,000 (103 to 104) cfu/100mL was set as the concentration of bacteria to be introduced to the device continuously during non-sampling periods. This concentration creates the conditions that the device will encounter during actual field use and indicates the ability of these organisms to "grow through" the device's bacteriological barrier.

Table 2 shows the ranges for each organism found within the indicated body of water. As shown, concentrations vary considerably, indicating the effect that environmental or seasonal conditions have on water quality.

Water treatment facilities in the U.S. use raw water quality information to determine appropriate treatment strategies for compliance with EPA drinking water regulations. The Information Collection Rule of 1996 required the EPA to compile data on the presence of certain microbes in addition to indicator organisms in drinking water sources. A summary of these is shown in Table 3. *wqp*

References for this article are available at www.wqpmag.com/lm.cfm/wq031005.

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