

# A Preliminary Survey of the Association of *Pseudomonas aeruginosa* with Commercial Whirlpool Bath Waters

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**Abstract:** Conditions in commercial whirlpool baths were investigated and populations of *Pseudomonas aeruginosa* surveyed. Conditions generally favored growth, and *P. aeruginosa* was demonstrated in 62.5 per cent of 24 samples of bath waters surveyed. Serotype 11, implicated in outbreaks of skin rash among bathers at whirlpool baths, was demonstrated most frequently, being isolated from 30 per cent of the 24 survey samples, and from 70 per cent of 20 additional samples from a single bath sampled on two days. (*Am J Public Health* 70:279-281, 1980.)

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Coincident with a recent rise in the popularity of whirlpool baths at health spas, tennis clubs, apartment complexes, and motels, outbreaks of a pruritic skin rash have been reported among bathers.<sup>1-7</sup> *Pseudomonas aeruginosa* serotype 11 was isolated from the skin of affected bathers in each outbreak and from waters of four of the implicated pools. The apparent association of this serotype with skin infections has been discussed elsewhere.<sup>8</sup> A preliminary survey of *P. aeruginosa* and conditions favoring their growth in whirlpool baths is reported here.

## Methods

Commercial whirlpool baths at eight locations in the Atlanta, Georgia area were examined for *P. aeruginosa* and for characteristics of water quality. During an initial survey, 24 samples were obtained between July and December, 1975. Total residual chlorine concentrations and temperatures were determined as described previously.<sup>9</sup> Organic carbon content of water samples was measured as total organic carbon (TOC) using a Beckman Model 915 TOC Analyzer,<sup>10</sup> and total Kjeldahl and ammonia nitrogen were measured on the Technicon Auto Analyzer according to procedures recommended by the manufacturer. Samples for bacteriological examination were obtained in sterile 150-ml bottles containing sodium thiosulfate<sup>10</sup> and inoculated immediately into five replicate tubes of Drake medium 10<sup>11</sup> or lactose broth.

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On November 7, 1975, 11 samples were obtained between 10:00 am and 9:30 pm to determine whether populations of *P. aeruginosa* varied with use of pool A. During a second investigation on December 14-15, 1975, a sample was obtained on the evening of December 14, after which sufficient chlorine bleach (Clorox) was added to provide a dosage of 50 mg/l which was permitted to circulate through the system prior to shutdown for the night. Pool waters were sampled periodically throughout the following day. Samples of floor surfaces surrounding the baths were obtained with Rodac plates containing Cetrimide agar (BBL). Exposed plates were incubated at 35° C for 48 hours. Procedures for the isolation and identification of *P. aeruginosa* from tubes of Drake medium 10 and Rodac plates were described previously.<sup>9</sup>

## Results

Conditions in whirlpool baths generally favored the development of *P. aeruginosa* (Table 1) and growth in filter-sterilized whirlpool waters has been demonstrated in the laboratory.\* Most probable numbers of *P. aeruginosa* varied from < 2 to > 2,400/100 ml, the median population in positive samples being 33/100 ml. While the frequency of isolation was greater at total residual chlorine concentrations of less than 2 mg/l than at 3 mg/l or greater, the species was isolated frequently from waters at the higher total residual concentrations.

Predominant serotypes among *P. aeruginosa* isolates (Table 2) were 6, 11, and 4. Eleven of the 38 isolates of serotype 6 originated from a single sample, making it the predominant serotype. On the other hand, serotype 11 was the most frequently demonstrated serotype, occurring in 29.2 per cent of samples. While serotype 6 was isolated from 20.8 per cent of samples, serotype 16 from 16.7 per cent, and serotypes 1 and 4 from 12.5 per cent, the demonstration of serotype 11 in nearly one-third of the samples was of particular interest in view of its involvement in whirlpool-associated skin rashes.

Daily variations in chemical characteristics and populations of *P. aeruginosa* were investigated at whirlpool A during normal operation on November 7 and following superchlorination on December 14, 1975 (Table 3). During normal operation populations varied little throughout the day, although a variety of serotypes was isolated (Table 4) and the data suggest a continuous shift in serotypes. Serotype 11 appeared in the water at 2:30 pm, and was predominant at 9:30 pm. *P. aeruginosa* was isolated from each of 11 floor samples obtained throughout the day. Since strains of serotype

**TABLE 1—Characteristics of Whirlpool Waters Surveyed**

Pool	No. of Samples	No. of Bathers at Time of Sampling	Temperature (°C)	pH	Total Residual Chlorine (mg/l)	Total Organic Carbon (mg/l)	Nitrogen		Most Probable Number of Bacteria per 100 ml		
							Total Kjeldahl (mg/l)	Ammonia (mg/l)	Presumptive Coliforms	Total Fluorescent <i>Pseudomonas</i>	<i>Pseudomonas aeruginosa</i>
A	4	1-3	31-39	7.1-7.3	0.4-3.0	60.5- 74.5	30.0-70.0	3.2-21.0	<2-33	5->2,400	<2->2,400
B	4	2-4	37-39	6.1-7.2	3.0	31.0- 77.5	29.0-49.5	3.0- 9.3	<2	<2-33	<2-33
C	4	1-3	36-39	6.1-7.8	3.0	6.0- 17.0	1.5-53.5	0.1- 8.4	<2-13	<2-13	<2-13
D	3	0	31-37	6.8-7.4	0.0-3.0	1.5- 7.0	3.5- 7.0	0.3- 1.8	<2-240	<2-920	<2-540
E	3	0	39-42	6.6-7.3	0.0-0.2	2.0- 3.5	3.0- 7.5	0.5- 1.8	<2-170	2-49	2-49
F	2	2-6	38	5.8-6.7	3.0	165.5-211.0	70.0-91.0	15.3-17.1	<2	<2	<2
G	2	1-2	37-39	7.2-7.4	0.0-0.2	26.0- 43.0	20.0-24.0	5.3- 8.1	<2-540	8-540	8-540
H	2	0	24-37	6.8-7.0	0.0	13.5- 14.5	8.5- 9.5	1.8- 2.0	<2	920->2,400	81-920

11 were obtained from five of 11 surface samples beginning at 11:30 am, this serotype may have been carried into the pool on the feet of bathers. However, the skimmer basket was sampled in the morning and evening, and each sample yielded only serotype 11.

**TABLE 2—*Pseudomonas aeruginosa* Serotypes Isolated from Whirlpool Waters Surveyed**

Serotype	Number of Isolates	Per Cent of Isolates	Number of Samples	Per Cent of Samples
1	10	9.0	3	12.5
3	3	2.5	1	4.2
4	17	14.5	3	12.5
6	38	34.0	5	20.8
9	3	3.0	2	8.3
11	24	21.5	7	29.2
14	3	3.0	2	8.3
16H	5	4.5	4	16.7
16H, 8, 4	4	3.5	1	4.2
Rough	5	4.5	3	12.5

As during normal operation, conditions in the whirlpool varied little through the day following superchlorination. *P. aeruginosa* was isolated from all samples examined. Prior to chlorination, the MPN of *P. aeruginosa* was 17/100 ml. Following chlorination, populations increased from a low of 14/100 ml at 11:30 am to 920/100 ml at 6:00 pm.

Serotype 11 was isolated prior to chlorination and from all but one post-chlorination sample. It was the predominant serotype isolated, with the exception of untypable isolates (Table 4). It was isolated also from five of six floor samples obtained throughout the day. Serotype 10 was isolated from floor surfaces at 11:30 am and 1:00 pm and serotype 3 at 1:00 pm. Both serotypes were isolated from pool waters only after they had been isolated from floor surfaces.

**Discussion**

The results obtained during the present brief investigations of eight whirlpool baths indicate that *P. aeruginosa*

**TABLE 3—Most Probable Numbers of Presumptive Coliforms and *Pseudomonas aeruginosa* in Whirlpool A during Full Day Sampling**

Date	Bacterial Group	Most Probable Number per 100 ml													
		1000a	1130	1230	1300	1330	1430	1630	1730	1800	1830	1930	2030	2100	2130
11-7-75 <sup>b</sup>	Presumptive Coliforms	<2	<2	2	—	<2	<2	<2	<2	—	<2	<2	<2	—	<2
	<i>P. aeruginosa</i>	49	49	26	—	23	79	49	49	—	49	110	49	—	70
12-14-75 <sup>c</sup>	Presumptive	<2	<2	—	<2	—	<2	<2	—	<2	—	<2	—	2	—
	<i>P. aeruginosa</i> <sup>d</sup>	31	14	—	23	—	540	130	—	920	—	280	—	920	—

<sup>a</sup> Hour of day  
<sup>b</sup> No. of bathers 0-10  
 Temp. (°C) 37.5-39.0  
 pH 6.3-6.5  
 Total chlorine residual (mg/l) 1.7-3.0  
 TOC (mg/l) 121-177  
 Total Kjeldahl nitrogen (mg/l) 37.0-45.0  
 Ammonia nitrogen (mg/l) 4.6-7.7  
<sup>c</sup> No. of bathers 0-15  
 Temp. (°C) 37.0-39.0  
 pH 6.1-6.4  
 Total chlorine residual (mg/l) 0.9-1.4  
 TOC (mg/l) 78-88  
 Total Kjeldahl nitrogen (mg/l) 28.0-29.5  
 Ammonia nitrogen (mg/l) 2.7-3.8

<sup>d</sup> Characteristics of whirlpool waters at 1715 prior to dosing with 50 mg/l of chlorine on 12-13-75  
 No. of bathers 3  
 Temp. (°C) 38  
 pH 6.4  
 Total chlorine residual (mg/l) 2.0  
 TOC (mg/l) 93.0  
 Total Kjeldahl nitrogen (mg/l) 37.5  
 Ammonia nitrogen (mg/l) 12.0  
 Presumptive coliforms (MPN/100 ml) <2  
 Total fluorescent *Pseudomonas* (MPN/100 ml) 17  
*P. aeruginosa* (MPN/100 ml) 17

**TABLE 4—*Pseudomonas aeruginosa* Serotypes Isolated from Whirlpool A during Full Day Sampling**

Date	Serotype	No. of Isolates	% of Isolates	No. of Samples	% of Samples
11-7-75	1	3	4.0	3	27.2
	3	1	1.3	1	9.1
	4	8	10.7	4	36.4
	8	3	4.0	2	18.2
	9	5	6.7	5	45.5
	11	12	16.0	6	54.6
	16H	4	5.3	2	18.2
	8,4	2	2.7	2	18.2
	16H, 4	10	13.3	5	45.5
	16H, 8	3	4.0	2	18.2
	16H, 8, 4	11	14.7	6	54.6
	Rough	8	10.7	6	54.6
	Untypable	5	6.7	4	36.4
	12-15-75 <sup>a</sup>	1	3	4.0	2
3		1	1.3	1	12.5
4		18	24.0	6	75
6		2	2.7	2	25
10		1	1.3	1	12.5
11		20	26.7	7	87.5
16H		1	1.3	1	12.5
8,4		2	2.7	2	25
Rough		5	6.7	3	37.5
Untypable		22	29.4	8	100

<sup>a</sup> Six strains of serotype 11 were isolated from sample obtained on 12-14-75 prior to superchlorination.

may be isolated readily from commercial baths. While many serotypes may be present, serotype 11 may be common in such environments. The species may persist even at total residual chlorine concentrations of 3.0 mg/l. High TOC and ammonia concentrations may impede the maintenance of free residuals. Furthermore, concentrations of nutrients, pH, and temperature appeared to favor growth.

It is clear, in view of reported outbreaks of skin rashes among bathers caused by *P. aeruginosa* serotype 11, that

regulation of whirlpool baths is important for the protection of bathers. Guidelines for the protection of bathers at swimming pools do not necessarily apply to whirlpool baths. The results of this investigation point to a need for more extensive studies to establish sources of *P. aeruginosa*, especially serotype 11, factors influencing its growth in bath waters, relationships between population densities and the incidence of skin rashes among bathers, and control of bath water quality.

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