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MICROBIAL QUALITY OF A MARINE TIDAL POOL

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ABSTRACT

The microbial quality of a marine tidal pool on South Africa's Atlantic coast was found to be inferior to that of the adjoining seawater (the latter complying with various water quality guidelines, the tidal pool failing). This seems to be due to pollution from the bathers using the pool.

KEYWORDS

Bathing water quality, microbial standards, South African marine recreational water quality guidelines, US EPA guidelines, EC bathing water directive, health risks, indicator bacteria, faecal contamination.

INTRODUCTION

Marine recreational activities form an integral part of the tourist industry in South Africa making the protection of the marine environment of particular economic concern. The South African coastline has a length of approximately 3000 km, of which an estimated 600 km is used for recreational purposes (Russell, 1992). Indicators of faecal pollution including the faecal coliforms and streptococci, and more specifically, *E. coli*, are used as water quality indicators in the marine environment. In South Africa, the guidelines for marine recreational waters, which are similar to those of the European Community, specify that 80% of samples in a year should have less than 100 faecal coliforms /100mℓ and that 95% of samples should have less than 2000 faecal coliforms /100mℓ (DWA&F, 1992). In the USA, the guideline specifies that the geometric mean of enterococci counts should be less than 35/100mℓ (USA EPA, 1986).

Marine tidal pools are artificial recreational structures which retain water at low tide and are flushed at high tide. Tidal pools provide conditions where bather densities are higher than those normally observed at bathing beaches along the South African coastline. Such high density bathing may cause an increased health risk to the bathers.

In this study the source of microbial pollution to a tidal pool was investigated. Both adjacent seawater which could contribute to possible faecal pollution and potential direct bather pollution were studied. The microbial quality of the marine tidal pool water was compared to South African and other marine water quality guidelines.

MATERIALS AND METHODS

Study site: A tidal pool along the Atlantic coastline of the Western Cape in South Africa was studied over the swimming season of 1992/93 (November to March).

Sampling: Sample sites included the shallow and deep ends of the marine tidal pool and the seawater immediately adjacent to the tidal pool. Composite water samples were collected at three fifteen minute intervals during mid-morning and mid-afternoon. The water samples were transported on ice to the laboratory and analysed within 2-4 hours of collection. A total of 192 samples were analysed.

Microbiological analyses: All water samples were analysed for the presence of faecal coliforms, *E. coli*, enterococci (faecal streptococci), staphylococci and coliphages. Membrane filtration methods using mFC agar for the enumeration of faecal coliforms, m-Enterococcus agar for the enumeration of enterococci (APHA, 1989) and BFR-O agar for the staphylococci were used (Borrego *et al.*, 1987). The 100 mℓ incorporation method of Grabow and Coubrough (1986) was used for the enumeration of coliphages using *E. coli* C as host. Confirmation of *E. coli* was performed using MUG media as described by Augoustinos *et al.*(1993) and Mates and Shaffer (1988).

Statistical analyses: Analysis of variance (ANOVA) techniques were used to test for significant differences between microbial water quality at the various sampling sites. Correlation analysis was used to assess whether microbial parameters described the relationship between water quality and bather density.

RESULTS

A wide range of bacterial counts was observed with maximum counts per 100ml of $2{,}3X10^4$, $1.5X10^4$, $8.8X10^2$, and $8.0X10^3$ for faecal coliforms, *E. coli*, enterococci and staphylococci, respectively (Table 1). Ten fold differences in bacterial counts were observed between water in the tidal pool compared to adjacent to the pool, but not for coliphages, with 80th percentiles for coliphage counts below or equal to 1/100ml (Table 1). Analysis of variance showed bacterial counts to be significantly higher in the shallow end of the tidal pool than in the deep end and in the seawater immediately adjacent to the pool (Table 2).

Bather numbers varied from 1 to 170 with an average number of bathers of 39 and 26 in the shallow and deep ends, respectively. In 80% of samples taken, bather numbers were less than 46 and 32 for the shallow and deep ends respectively. To analyse the relationship between the microbial variables and bather numbers, linear regression analyses of the logs of the microbial counts and bather numbers were calculated (Table 3) for the shallow and deep ends of the pool.

The logs of faecal coliforms, *E. coli*, staphylococci, and enterococci were found to be significantly correlated to bather numbers in both the shallow and deep ends (significant at the 99% level). Coliphages were not significantly correlated with bather numbers and therefore coefficients are not given in Table 3. The base loads (counts/100ml when bather numbers are zero; calculated from the intercept of the regression line, $y=a+bx$) of the water for the different microbial parameters varied considerably according to whether one considers the shallow or deep end of the pool. Slopes of the regression lines varied for the two ends of the pool, indicating that the relationship between bather numbers and microbial densities differed for the two sites. Base loads were higher in the shallow end of the pool for all microbial parameters. The base loads for the deep end of the pool were very similar to the geometric means of seawater adjacent to the pool (Table 2).

Table 1. Microbial water quality of marine tidal pool and seawater adjacent to the pool

Sample site	Microbial Parameters (counts/100ml)				
	Faecal coliforms	*E. coli*	Enterococci	Staphylococci	Coliphages
Shallow end					
n (number samples)	64	64	64	64	64
geom. mean	214	87	49	214	.2
maximum	23000	15364	882	8000	215
minimum	7	3	3	6	0
80th percentile	1360	271	127	830	0
95th percentile	3687	2465	470	3070	28
Deep end					
n (number samples)	64	64	64	64	64
geom. mean	46	10	11	94	.2
maximum	20000	6607	515	5000	90
minimum	1	0	0	1	0
80th percentile	300	88	52	395	0
95th percentile	3015	1085	360	1360	10
Seawater adjacent to pool					
n (number samples)	64	64	64	64	64
geom. mean	13	3	6	19	.2
maximum	2000	329	253	1270	315
minimum	1	0	0	2	0
80th percentile	58	10	22	63	0
95th percentile	308	66	100	395	3

Table 2. Analysis of variance of microbial water quality at different sampling sites

Microbial parameters	Significance level	F ratio
Faecal coliforms	0,0476*	3,095
E. coli	0,0412*	3,243
Enterococci	0,0004*	8,261
Staphylococci	0,0016*	6,693
Coliphages	0,7503	0,288

* Significant at the 95% level

Table 3. Linear regression analysis of log microbial counts and bather densities

Bather numbers vs	Shallow/deep end of tidal pool	Coefficient R	Base load (counts/100ml)
Log faecal coliforms	Shallow	0,51	73
	Deep	0,55	18
Log *E. coli*	Shallow	0,39	34
	Deep	0,69	6
Log enterococci	Shallow	0,78	17
	Deep	0,46	6
Log Staphylococci	Shallow	0,55	88
	Deep	0,49	57

DISCUSSION

The tidal pool water quality did not comply with either the South African marine recreational water quality guidelines, the European Community bathing water directive or to the US-EPA criteria for marine recreational water, whereas the seawater adjacent to the tidal pool complied with all guidelines.

Correlation analyses between indicator organisms and bather densities show that a significant correlation exists between all indicators tested and bather numbers with the exception of coliphages. In addition, coliphages were found to occur in very low numbers in this study in comparison to the

high numbers of the other indicator organisms detected. The results of this study indicate that coliphages are not suitable indicators of marine water quality, whereas other researchers have found that coliphages are appropriate indicators of remote pollution in the marine environment (Cornax *et al.*, 1991; Grabow *et al.*, 1984).

The poorer water quality found in the pool is very likely to have originated from the bathers themselves due to the relatively high bather densities. The high correlations between staphylococci counts and bather densities (although similar correlations were obtained with other microbial indicators) clearly indicate the implications of bather pollution, rather than contamination from polluted rivers or stormwater entering the sea. The base loads for the deep end of the pool being very similar to the geometric means of seawater adjacent to the pool, also supports this conclusion. Fattal and Shuval (1988) also found that pollution in bathing areas with restricted water exchange to be caused by contamination from the bathers themselves. The findings of this study, which indicate the bathers as a source of pollution, has implications on the management of marine recreational areas.

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