

The amount of domestic sewage discharged into marine environment is increasing daily. These discharges produce physico-chemical and ecological disturbances, the importance and extent of which depend on several factors, such as: intensity and frequency of the discharges; dilution capability of the receiving marine ecosystem; and self-depurating processes in the sea. However, the most serious consequence derived from sewage discharges is related to the health-hazard associated with the recreational use of the contaminated-marine seawaters. There is considerable evidence suggesting the short-lived viability of most enteric pathogens outside the intestinal tract, except for the enteric viruses.

Several authors have suggested the use of bacteriophages as enteric viral pollution indicators, because of their similar behaviour and survival in the aquatic environment (SIMKOVA & CERVENKA, 1981; STETLER, 1984; BORREGO et al., 1990). However, the great variety of bacteriophage groups is an important shortcoming to the general use of the phages as viral indicators. Therefore, a comparative study on the survival capabilities of different bacteriophage groups is needed to establish their real validity as viral indicators.

Five bacteriophage groups (coliphages C, coliphages K12, F-specific coliphages, somatic *Salmonella* phages and phages active against *Bacteroides fragilis*) were comparatively studied on the basis of their survival and dispersion in littoral seawater. In all the cases, the double agar layer technique was performed for the phage assays, using as host bacteria the following: *Escherichia coli* C (ATCC 13706) for coliphages C; *E. coli* K12 Hfr (PC0008) for coliphages K12; *Salmonella typhimurium* WG49 for F-specific phages; *S. typhimurium* WG45 for somatic *Salmonella* phages and *B. fragilis* HSP40 for *Bacteroides* phages. Phage methodologies used in this study were those described by CORNAX et al. (1991).

Survival studies were conducted applying the techniques described by BORREGO et al. (1990) and CORNAX et al. (1991), and the time of residence or distance of dispersion were calculated according to the expression:

$$C = C_0 \times 10^{-X/X90}$$

X being the time or distance, and X90 the characteristic value of time or distance in which is achieved the 90% of disappearance.

Comparative survival characteristics of the different phage groups, measured both in time of residence and distance of dispersion in the seawater are given in Table 1.

All the bacteriophage groups showed higher survival capabilities than coliforms and generally a higher dispersion too. Inactivation rates of bacteriophages in the marine environment were similar to those of fecal streptococci. However, in laboratory conditions the bacteria are affected at high degree by seawater. This finding may be explained by the fact that in laboratory conditions the effects of adsorption, precipitation and sunlight are omitted, being these the main factors involved to the virucidal effects of seawater (BITTON, 1980; KAPUSCINSKI & MITCHELL, 1983). On the contrary, F-specific phages possessed the lowest survival on laboratory conditions (5.7 h), which is in contradiction with the results obtained by several authors (AYRES, 1977; YATES et al., 1985; HAVELAAR, 1987).

In conclusion, on the basis of the higher survival in marine environment, coliphages seem to be appropriate indicators of both, virus and bacterial pollution of this ecosystem.

Table 1. Comparative survival capabilities of different phage groups and indicator microorganisms in seawater.

	D90 (M)	T90 (h)		
		Estuary	Open sea	Lab. Conditions
Total coliforms	215	0.73	0.26	3.7
Fecal coliforms	241	0.83	0.24	3.6
Fecal streptococci	346	0.69	0.34	8.0
Coliphages C	293	0.79	0.33	>15
Coliphages K12	284	NT	0.38	>15
F-specific phages	322	0.84	0.33	5.7
<i>Salmonella</i> somatic phages	206	0.70	NT	9.6
<i>Bacteroides</i> phages	170	0.67	NT	7.3

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During the bathing, season 1991, Goletta VERDE for the Lega per l'Ambiente conducted the campaign for evaluation of sea water quality along the Italian coastline. The bacterial quality of the recreational water was assessed by the usual fecal indicators (total and fecal coliforms and fecal streptococci); as supplementary indicator, the occurrence of staphylococci was investigated.

The former microorganisms can indicate the presence of enteric pathogens. However, infections in bathing waters are not limited to enteric diseases but extend to the skin, ears, nose and throat (WHO, 1986). Staphylococci are harboured in the mucous membranes, on the skin and hair follicles of warm-blooded animals. They can be washed out under all conditions of swimming so that their origin in bathing water is undoubtedly human activity. These microorganisms have been recommended as an index of bather pollution in swimming pool, as in lake and marine waters where low water exchange is present (FAVERO, 1985).

This investigation reports results obtained by analyzing 200 sea water samples collected along the Italian Coasts.

The area studied extends along the beaches of 10 Italian Regions.

As stated by the Italian legislation (DPR 470/82) on recreational bathing water total coliforms, fecal coliforms and fecal streptococci were enumerated. Moreover on the same samples the analyses for staphylococci were carried out.

All monitoring was done by membrane filtration (MF), total coliforms and fecal coliforms recovery was performed by using Endo and Teepol media, respectively. Fecal streptococci were enumerated on Azid medium and staphylococci on Vogel Johnson agar. For all the microorganisms 10 ml of seawater were filtered.

The data presented here indicate absence of correlation between the presence of fecal indicators and staphylococci. That can indicate that the usual bacterial species used as index of presence of enteric pathogens may, by themselves, not be adequate to ensure the bacterial safety of recreational waters in relation to water washed diseases. In fact, some beaches could be considered suitable for bathing when evaluated through the enumeration of fecal indicators. However, in the same seawater samples staphylococci occurred. It could be a suggestion for monitoring staphylococci as a supplementary indicator in overcrowded beaches because they will add valuable information on the sanitary quality of the seawater.

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