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SANITARY AND AESTHETIC QUALITY OF THE COASTAL WATERS OF SPAIN

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ABSTRACT

A program to evaluate sanitary and aesthetic conditions of the beaches and coastal areas of Spain has been carried out during the 1977 and 1978 summer seasons. Microbiological quality of sea water was interpreted according to national and international standards. Indicator organisms concentration showed a considerable statistical variation with time while low values for fecal coliform concentration were repeatedly obtained. Results from an epidemiological survey indicate that: 1) there exists a satisfactory correlation between a TC80 value for total coliform concentration in the range 150-2 500 TC/100 ml and acceptable aesthetic conditions of sea water, 2) skin, eyes and ear infections are the most frequent ailments suffered by recreationists of coastal waters and 3) mycosis appears to be the single ailment significantly associated to sea water microbiological quality. Studies are under way to further investigate the possible association between sea water quality and public health.

INTRODUCTION

A program to evaluate sanitary and aesthetic conditions of the beaches and coastal areas of Spain was established by the Environmental Health Service in 1977. The program is operating within the framework of the MED-VII Pilot Project, a part of the Mediterranean Action Plan jointly coordinated by the World Health Organization (WHO) and the United Nations Environment Programme (UNEP).

Two pilot zones have been established in Malaga and Tarragona, where studies are being conducted in systematic form. In addition, Public Health Authorities from other coastal provinces have contributed substantial amounts of data and information.

OBJECTIVE

The objective of the program is to obtain statistically significant data, scientific information and technical principles to evaluate the degree of pollution at the beaches and coastal areas of Spain, particularly in those aspects related to public health.

The specific objectives of the program are: 1) to appraise the public health effects derived from recreation on coastal waters, 2) to gather experimental information for establishing coastal water quality standards and 3) to gather experimental evidence of the feasibility of this type of study.

EXPERIMENTAL INFORMATION

The study has been carried out during the 1977 and 1978 summer seasons. The two main categories of data obtained from the Provincial Public Health Authorities were: 1) records of microbiological water quality of selected beaches and 2) records of a standardized epidemiological study carried out among recreationists at those beaches.

Microbiological water quality was evaluated in terms of total coliform (TC) and fecal coliform (FC) concentrations. The method of analysis generally employed was the multiple dilution technique (MPN) except at Tarragona where the membrane filtration technique (MF) was used.

Statistical parameters of microbiological water quality were graphically derived by fitting a lognormal probability distribution to the experimental results. From the straight line obtained in a lognormal probability paper the microbial concentration not surpassed a given percentage of the samples was calculated. Following this criteria, TC50 represents the total coliform concentration not surpassed in 50% of the samples. Finally, the geometric standard deviation was computed in every beach for the two indicator organisms considered.

The three basic categories of information obtained from the epidemiological survey were: 1) the demographic and bathing habits of recreationists, 2) the qualitative opinion of recreationists about the state of cleanliness of the beach, the sea water and the food and beverage establishments and 3) the ailments suffered by recreationists during their stay at the beach, together with their personal opinion and that of the medical doctor reportedly consulted on the positive or negative association between the ailments suffered and bathing at the beach.

The interpretation of the epidemiological data was based on the morbidity rate of different ailments, obtained considering those cases with a positive statement, both personal and from the medical doctor, for the ailment-bathing association as well as a fraction of the cases with only a positive personal opinion on that same association.

RESULTS

The following results were derived after two years of study and consequently are of more general application than those initially reported by Mujeriego and co-workers (1978).

Microbiological Quality

To evaluate the present state of microbiological quality of coastal waters the

following water quality criteria and standards were considered: 1) the preliminary WHO coastal water quality criteria (WHO, 1974, 1977). Established in terms of E. coli they can be expressed as EC50 = 100 EC/100 ml and EC90 = 1 000 EC/100 ml, 2) the present Spanish standards for coastal water quality (MOPU, 1977); its numerical values are EC50 = 200 EC/100 ml and EC90 = 1 000 EC/100 ml, 3) the European Economic Community (EEC) water quality criteria (EEC Coucil, 1975). Though no specific frequency is associated with the numerical values, the following are believed to adequately interpret the aim of the Directive, TC50 = 500 TC/100 ml, TC90 = 10 000 TC/100 ml, FC50 = 100 FC/10 ml and FC90 = 2 000 FC/100 ml, and 4) the coastal water quality standard established by the California Department of Public Health (1943) whose numerical value is TC80 = 1 000 TC/100 ml.

It is appropiate to indicate that the last standard is the only one based on a quantified cause-effect relationship. As the original report states, when the coliform count is lower than 1 000 TC/100 ml the aesthetic conditions of the beach are acceptable in terms of absence of sewage-born materials.

Table 1 summarizes the relative distribution of a sample of beaches according to the four water quality standards considered. The beaches included in this analysis are among those widely used during the summer season.

TABLE 1. Microbiological Quality of Coastal Waters

Quality Criteria	Number of Beaches		
	Total	Satisfactory	Unsatisfactory
WHO, 1974	106	88 (83%)	18 (17%)
MOPU, 1977	106	90 (85%)	16 (15%)
EEC Directive, 1975	106	75 (71%)	31 (29%)
California, 1943	66	36 (55%)	30 (45%)

An analysis of Table 1 reveals that: 1) approximately 15 to 30% of the beaches could not be considered satisfactory from the microbiological point of view and 2) approximately 45% of the beaches could not be considered aesthetically satisfactory. This second result will be subsequently compared with the actual aesthetic rating granted by recreationists.

Indicator Organisms Variability

A statistical analysis of the observed variability of total coliform and fecal coliform concentrations was performed based on the geometric standard deviations derived from 44 beaches. Of these, 17 correspond to Malaga and 27 to Tarragona.

Table 2 summarizes the 95% confidence interval for the geometric standard deviation of total and fecal coliform concentrations. Also shown in Table 2 are the corresponding intervals for the C90/C50 ratios.

Total coliform concentrations measured at Malaga beaches show a larger variability

than that registered at Tarragona beaches. Although the analytical method used at both laboratories was not the same, MPN at Malaga and MF at Tarragona, it is considered that this fact does not account for the observed differences. Studies under way using the MF method are expected to clarify the relative contribution of analytical method and natural conditions of the beaches on the variability of indicator organisms concentrations.

TABLE 2. 95% Confidence Interval for Statistical Parameters of Total and Fecal Coliform Concentrations

Province	Beaches	Geometric Standard Deviation		C90/C50 Ratio	
		TC	FC	TC	FC
Malaga	17	2.7 ± 1.0	2.1 ± 0.4	10 - 110	10 - 20
Tarragona	27	1.5 ± 0.4	2.6 ± 0.4	5 - 10	15 - 40

Confidence intervals for the C90/C50 ratio clearly illustrate the variations most likely expected in sea water quality. These results are of quite practical interest when setting realistic and feasible coastal water quality standards.

Indicator Organisms Concentrations

To investigate the relative concentrations of total coliform and fecal coliform as recovered analytically from each sea water area, a comparative study was made on the statistical concentrations derived at the previous 44 beaches. The results of this study reveal that: 1) there is no simple expression relating corresponding concentrations of total and fecal coliform neither when considering the 50% nor the 90% frequency values and 2) only when comparing the TC50 and the FC50 values derived at the beaches of Tarragona there appears to be a linear relationship between ln TC50 and ln FC50 ($r=0.56$), resulting in an overall TC50/FC50 ratio of approximately 16.

There is enough evidence from this study that a considerable number of fecal coliforms known to be present in the water samples, as evidenced during the total coliform test, do not appear on subsequent analysis for fecal coliform. As a result, reported fecal coliform concentrations are lower than expected, bringing the TC/FC ratio to considerable high values. A satisfactory explanation to this question is of outmost importance considering that most microbiological water quality criteria are referred in terms of fecal coliform concentrations.

Epidemiological Survey

The epidemiological survey included a total of 16 693 valid questionaires distributed among 10 coastal provinces. The number of persons interviewed at each province was highly variable, with one province contributing slightly more than 10 000 questionaires, while 5 other provinces contributed between 700 and 1 800 questionaires each. This great disparity was unavoidable and brought considerable difficulty when interpreting the data. Demographic charateristics of the sample surveyed

are summarized in Table 3.

TABLE 3. Demographic Characteristics of Sample Surveyed

Age Group	No.	%	Sex Group	No.	%	Nationality	No.	%
3 - 15	6 380	38	Men	8 002	48	Spanish	13 472	81
16 - 25	4 539	27	Women	8 239	49	Foreigners	2 514	15
26 - 45	3 732	22						
46 - 65	1 197	7						
more 65	406	2						

Aesthetic Quality

Table 4 summarizes the distribution of beaches, sea water and food and beverage establishments at the beach according to their degree of cleanliness, as measured by the mean personal opinion of the recreationists interviewed at a sample of 48 beaches.

TABLE 4. Aesthetic Quality of Coastal Areas[a]

Component	Excellent	Good	Acceptable	Bad	Very Bad
Beach	1	6	24	17	0
Sea Water	1	3	23	20	1
Food & Beverage Establishments	1	8	35	4	0

a) Sample of 48 beaches from 9 provinces comprising 11 585 questionaires

From Table 4 the following conclusions can be drawn: 1) approximately 50% of the beaches and coastal waters are considered "acceptable" by recreationists, while this same rating was granted to 73% of the food and beverage establishments at the beach, 2) coastal water is the component with the lowest rating, only 3% of the sea water zones were considered above "acceptable" as compared to 15% of the beaches and 17% of the food and beverage establishments and 3) sea water is the component with the largest proportion of "unacceptable" cases, 45%, followed by the beaches with a 35% and by the food and beverage establishments with an 8%.

There is an excellent agreement between the percentage of sea water zones considered aesthetically "unacceptable" by recreationists and the percentage of sea water zones considered unsatisfactory according to the California water quality standard, as shown in Table 1.

Public Health

Summarized in Table 5 are the overall morbidity rates for the ailments more frequently affecting recreationists of coastal waters. The 95% confidence interval was obtained from the corresponding morbidity rates of 10 provinces considered as cluster units.

Inspection of Table 5 reveals skin and eyes infections as the ailments more frequently affecting recreationists, followed by ear and nose infections; allergies, diarrheas and throat infections show a relatively lower incidence.

TABLE 5. Confidence Interval for Morbidity Rates of Ailments Affecting Recreationists of Sea Coastal Areas [a]

Ailment	Morbidity Rate, % (α = 0.05)
Pimples	3.9 ± 1.4
Eyes Infection	3.8 ± 1.1
Mycosis	3.4 ± 0.7
Ear Infection	2.9 ± 0.6
Nose Infection	2.5 ± 0.6
Allergies	1.7 ± 0.4
Diarrheas	1.6 ± 0.7
Throat Infection	1.4 ± 0.4

a) Based on 16 693 questionaires from 10 coastal provinces.

Aesthetics and Microbiological Water Quality

An attempt has been made to analyze possible relationships between aesthetic rating of sea water, as obtained from the personal opinion of recreationists, and microbiological water quality of sea water measured by indicator organism concentrations. The analysis was based on 8 210 questionaires distributed among 25 beaches of 5 provinces.

Summarized in Table 6 are the correlation coefficients and most likely ranges of total coliform concentrations associated with the main categories of aesthetic quality. There was no detectable correlation between aesthetic conditions of sea water and any of the fecal coliform concentration statistical parameters.

Results in Table 6 indicate that: 1) the upper total coliform concentration level, TC90, provides the better characterization of the aesthetic quality of sea water, as illustrated by a correlation coefficient of 0.81, 2) TC80 values in the range 150 - 2 500 TC/100 ml represent fairly well what is considered as "acceptable" aesthetic conditions for sea water; as expected this value agrees quite well with the California standard of TC80 = 1 000 TC/10 ml , and 3) there is no correlation between sea water quality and fecal coliform concentration. This last result further supports the observation made previously that fecal coliform concentrations

obtained in this study do not represent adequately the microbial content of sea water.

TABLE 6. Aesthetic and Microbiological Water Quality [a]

Aesthetic Rating	Total Coliform , TC/100 ml		
	TC50 (r=0.48)	TC80 (r=0.75)	TC90 (r=0.81)
Unsatisfactory	> 400	> 2 500	> 8 000
Acceptable	70 - 400	150 - 2 500	200 - 8 000
Satisfactory	< 70	< 150	< 200

a) Based on 8 210 questionaires from 25 beaches of 5 provinces.

Water Quality and Public Health

A considerable amount of additional data and information has been gathered since preliminary results of this study were reported (Mujeriego and co-workers, 1978). Based on the data and information available from this two-year phase of the study, a correlation analysis was made to investigate the possible relationship between microbiological quality of sea water and public health effects among recreationists.

A total of 8 210 questionaires from 25 beaches of 5 provinces were used on the analysis. The health ailments considered were those with the higher estimated morbidity rate. The microbiological water quality indicators were the total coliform and fecal coliform concentrations.

The results of the analysis were: 1) there is no statistically significant correlation between morbidity rates for pimples, eye, ear and nose infections and water quality expressed in terms of total coliform, 2) there is a statistically significant correlation between mortidity rate for mycosis and total coliform concentration, the correlation coeffic ent increases from r=0.52 for TC50 to r=0.67 when using TC80 and up to r=0.73 when TC90 is considered, and 3) there is no apparent correlation of any of the above ailments and fecal coliform concentrations.

Based on these results a specific program has been established to further investigate the possible association between water quality and public health. A selected number of beaches has been proposed, covering a wide range of microbiological water quality, in which water quality will be monitored. In addition, a more specific epidemiological survey will be performed, in which a minimum and approximately equal number of questionaires will be collected at every beach, as derived from statistical considerations of the morbidity rates already estimated.

CONCLUSIONS

From the studies carried out on the sanitary and aesthetic quality of the beaches and coastal areas of Spain, the following conclusions can be drawn:

1. Aproximately 15 to 30% of the sea water areas studied could not be considered microbiologically satisfactory, according to national and international standards.

2. Geometric standard deviations of total and fecal coliform concentrations of sea water showed a considerable geographic variation. Actual values of this statistical parameter are of great practical interest when establishing feasible water quality standards.

3. Fecal coliform concentrations obtained under the environmental and laboratory conditions of this study do not represent adequately the actual microbial content of sea water.

4. Sea water is the coastal area component with the largest proportion of unacceptable cases, as derived from the personal opinion of recreationists. Approximately 45% of the sea water areas studied were qualified as unsatisfactory by recreationists, in excellent agreement with a similar proportion obtained when applying the California water quality standard.

5. Total coliform concentration appears to adequately characterize the aesthetic quality of sea water as expressed by recreationists. An interval for TC80 of 150 - 2 500 TC/100 ml is significantly associated with an acceptable rating from recreationists.

6. Skin, eye, ear and nose infections are the most frequent ailments affecting recreationists of sea coastal areas. Diarrheas have a comparatively lower incidence.

7. There is no statistically significant association between pimples, eye, ear and nose infections and sea water quality expressed in terms of either total coliform or fecal coliform concentrations.

8. There is a statistically significant association between mycosis and sea water quality expressed in terms of total coliform concentration.

Studies are being conducted to further evaluate the possible association between sea water quality and public health among recreationists.

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