AN ASSESSMENT OF THE IMPACT OF THE PROPOSED EU BATHING WATER DIRECTIVE ON IRISH COASTAL BATHING AREA COMPLIANCE.

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ABSTRACT
An assessment of the impact of the new microbial water quality standards of the proposed EU Bathing Water Directive on the classification of designated Irish coastal bathing areas is presented. The new standards are applied retrospectively to the microbial water quality results for the bathing seasons of 1999, 2000 and 2001, and the outcome is compared with that recorded under the present Bathing Water Directive. A Microsoft EXCEL application was developed to generate the retrospective bathing area classifications according to the proposed Directive (Excellent, Good, Poor). It was found that the number of Irish coastal bathing areas not attaining 'Excellent' classification (as would be required at present for the Blue Flag award) was *trebled*; the number attaining 'Good' classification was increased by about 50%, and the number attracting 'Poor' classification (equivalent to 'Fail' under the present Directive) was increased *nine-fold*. Some of the shortcomings of the proposed Directive and suggestions for its revision are discussed.

Keywords: water quality, bathing, Directive, catchment, coastal, microbial, indicator organism, compliance

INTRODUCTION
Under the present Bathing Water Directive (EEC 1976), for designated bathing areas to comply with the Mandatory (Imperative) or the more stringent Guide microbial water quality standard, a certain percentage of the faecal indicator organism concentrations found there during the period of a bathing season must not exceed certain threshold levels, viz. Table 1.

Table 1. Guide and Imperative Limits in EU Directive EEC/76/160, and National Limits in Irish SI 155/1992.

Indicator organism	Limit value (number of organisms/100 ml) EU Guide	EU Imperative	Irish National
Total coliforms	500[a]	10000[c]	5000[a]
Faecal coliforms	100[a]	2000[c]	1000[a]
Faecal streptococci	100[b]	NS[d]	300[c]

Notes: a. 80% compliance required.
b. 90% compliance required.
c. 95% compliance and no two consecutive exceedances required.
d. Not specified.

The proposed Bathing Water Directive (Commission of the European Communities 2002) provides for the "classification" of designated bathing areas based upon 95 percentile evaluation of the $\log_{10}$ normal probability density function of all the microbiological data acquired from the particular bathing area during the preceding three consecutive years (Table 2). 'Excellent' classification would be attained where the upper 95 percentile (95%ile) concentrations of intestinal enterococci (IE) and Escherichia coli (EC) did not exceed 100 and 250 colony-forming units per 100 millilitres (cfu/(100 ml)) respectively; 'Good" classification would require non-exceedance of 200 IE and 500 EC cfu/(100 ml) 95%ile values; where the 'Good' classification thresholds were exceeded a bathing area would be classified as 'Poor'. The 95 percentile concentration is to be derived as follows:

1. take the $\log_{10}$ value of the microbial data,
2. calculate the arithmetic mean (μ) and standard deviation (σ) of the $\log_{10}$ values,
3. calculate the upper 95 percentile point of the data probability density function from the following equation:

$$\text{Upper 95\%ile} = \text{antilog}\,(\mu + 1.65\,\sigma) \qquad (1)$$

Table 2. Upper 95%ile values pertaining to Excellent and Good Quality classification specified in the proposed EU Bathing Water Directive 2002/0254 (COD).

Microbial Parameters	Excellent Quality *(guide)*	Good Quality *(obligatory)*
Intestinal Enterococci	100	200
Escherischia coli	250	500

Importantly, the faecal indicator organisms specified by the present and the proposed Bathing Water Directives are different (FC and FS vs. EC and IE). Also, the present Directive speaks of Mandatory (Imperative), Guide compliance and Fail, while the proposed Directive refers to Excellent, Good and Poor classifications.

The microbial water quality standards for the proposed Directive are more stringent than the present standards. A bathing area attaining an upper 95%ile value of 200 IE and classified as Good under the proposed Directive would carry the average probability of one case of gastroenteritis for 20 exposures, whereas it is one case for approximately eight exposures for the Mandatory standard of the current Directive (WHO 2001), allowing that, technically, the Mandatory standard is not a "percentile point" but a "percentage compliance" (see Bartham and Rees 2000, p.143 et seq.). Some decline in the current high level of compliance of Irish bathing waters (designated in Irish Statutory Instrument 2001) should be expected on application of the proposed standards; the work reported here sought to evaluate the extent of this decline.

METHODS

The analysis presented in this report concerns only the designated coastal bathing areas of the Republic of Ireland, the nine designated freshwater bathing areas are not included.

Microbial water quality data for 131 bathing areas were provided by all relevant Local Authorities, and were compiled as received into an "all-IRL" data set. A three year period was analysed, 1999 to 2001. While for most bathing areas, the data was for the bathing season (mid-May to end of August), for some areas data was included for a greater period. The data set is not complete for every bathing area, particularly for 2001; one bathing area (Stroove) was first designated in 2001.

The data set was processed using the Microsoft EXCEL application to generate the retrospective bathing area classifications according to the proposed Directive. A 1:1 conversion factor was applied to the retrospective microbial water quality results (FC and FS) for the bathing seasons of 1999, 2000 and 2001 to generate an *equivalent* EC and IE data set (i.e. FC concentrations used for EC concentrations and FS concentrations for IE concentrations). The *equivalent* data set was then examined for compliance with the proposed Bathing Water Directive. Finally, for comparative purposes, the compliance classifications of the present Directive are reclassified according to the proposed Directive as follows: Guide reclassified as Excellent; Mandatory reclassified as Good; Fail reclassified as Poor.

On points of detail concerning the processing of the data supplied: where concentrations were indicated as "<" the number given was taken (i.e. <10 taken as 10); for ">", the number was incremented by 1, i.e. >2000 FC taken as 2001 (Fail) or >100 FS taken as 101 (Fail); where the concentration was given as TNTC, for FC it was taken as 2001 (Fail) and for FS it was taken as 101 (Fail). The effect of this, following processing as the 95%ile, was to minimise the standard deviation of the data of the particular bathing area, tending to enhance favourable classification. Simply to leave out such data (e.g. leave out some of the 'Fails') would enhance even further. To facilitate data processing, zero values were changed to value 1 to allow the $\log_{10}$ step, i.e. zero values not excluded; adding 1 cfu/(100 ml) had negligible effect in the 95%ile calculation.

Performances of individual bathing areas under the present and the proposed Directives were compared using the EXCEL-generated classifications and the compliance categories reported to the EU (as published on http://europa.eu.int/water/water-bathing).

RESULTS AND DISCUSSION

The overall National impact of the proposed microbial water quality standards is presented in Table 3.

On the basis of the analysis of the 1999-2001 data set, under the proposed Directive:

- the number of Irish coastal bathing areas not attaining 'Excellent' classification (as required at present for the Blue Flag award) would be *trebled*;

- the number attaining 'Good' classification would be increased by about 50% (the number results from the number of bathing areas reduced from 'Excellent' and the number reduced to 'Poor' classification);

- the number attracting 'Poor' classification would be increased *nine-fold*; as mentioned above, the 'Poor' classification under the proposed Directive is regarded as equivalent to 'Fail' under the present Directive, although there is conditional relief from having to close such areas for bathing (Article 13.2).

Trends in the year on year classifications are summarised in Table 4.

Table 3. Retrospective (1999-2001) classification of designated Irish coastal bathing areas based on the present Bathing Water Directive (Excellent = Guide compliant; Good = Imperative compliant; Poor = Fail) and on the proposed Directive.

Classification	% of bathing areas in class	
	Present Directive	**Proposed Directive**
Excellent	90	69
Good	8	13
Poor	2	18
Total:	100	100

Table 4. Retrospective (1999-2001) classification based on the proposed Bathing Water Directive for each of 3 years for Irish designated coastal bathing areas.

Class	NUMBER IN CLASS			PERCENTAGE IN CLASS		
	1999	**2000**	**2001**	**1999**	**2000**	**2001**
Excellent	69	84	53	57	71	65
Good	22	17	14	18	14	17
Poor	30	18	15	25	15	18
Total:	121	119	82	100	100	100

Improvement towards Excellent classification is seen comparing the 2000 and 1999 classifications. Some reversal on 2000 is seen for 2001, but the data set needs to be completed and any conclusion is premature.

Analysis of the effect of "Poor" classifications for individual years on the three-year classification is presented in Table 5; the analysis caters for bathing areas for which data was not available for the full three years.

Table 5. Breakdown of "Poor" bathing area classifications by individual bathing season(s).

Number of years		No. of bathing areas classified as 'Poor' -	
for which data was recorded for 'Poor' bathing areas	**when 'Poor' bathing areas were so classified**	**in individual year(s)**	**over combined years**
3	All three	9	9
	Two out of three	5	5
	One out of three	13	0
2	All two	4	4
	One out of two	3	2
1	One	2	2
	Total:	36	22

The analysis (Table 5) shows that provided three years are taken into account, 'Poor" classification of a bathing area in just one year may not necessarily result in 'Poor" classification for the three-year period. The picture is less clear where bathing area data was incomplete, i.e. not recorded for one or two of the years. It is reasonable that a one-year 'Poor" classification may be 'diluted out' in a large three-year data set.

An underlying assumption of the proposed Directive is that the 95%ile values for EC and IE are related by the factor 2.5. The factor obtained in an analysis of the Irish coastal bathing area data for the years 1999-2001 is 3.2. However the 'missmatches' between classifications using the two indicator organisms separately were relatively few. Excellent classification was attained by 94 bathing areas on the basis of the EC standard alone and 88 with IE alone; likewise 12 attained Good classification with EC alone and 19 with IE alone; finally, 16 were rated Poor with EC alone and 15 with IE alone.

CONCLUSIONS

It is shown above that the increased stringency of the proposed bathing water directive would reduce the compliance levels of Irish coastal bathing areas significantly, and similar impacts have been estimated by some EU Member States. In this light, the proposed Directive has come under considerable scrutiny, leading to concern about perceived shortcomings and to proposed revisions. Discussion of two issues that have emerged as a result of the work reported here now follows.

Where the number of measurements taken for the required three bathing seasons is low, occasional extreme values impact considerably on the 95%ile value (by enlarging the standard deviation component of the 95%ile calculation). Notably, occasional low micro-organism counts that indicate improved quality, although lowering the average three-season value appropriately, contribute through the standard deviation to downgrading of the water quality classification, thereby 'punishing good'! The severe effects of the standard deviation component of the 95% calculation might be minimised if the number of measurements over the three-seasons was large (100 measurements perhaps); however, for example the proposed Directive would require just 24 measurements for the Irish bathing season (fortnightly monitoring over three sixteen-week bathing seasons for 'Poor' bathing areas and less for the better quality areas).

There is no certainty that water quality improvements obtained under the EU Water Framework Directive (European Union 2000), that is focused on chemical and ecological quality, will effect parallel improvements in microbial water quality. This adds to the concern about increased water quality management costs in achieving compliance with the more stringent standards of the proposed Bathing Water Directive. In particular, high costs would arise in ameliorating the negative influence of high rainfall events on bathing area compliance that might involve substantial improvements to sewerage infrastructure and changes in agricultural practices. Awareness of this influence derives from a number of catchment studies published within the past ten years. A study of the Dargle catchment in Ireland and the Afon Rheidol and Afon Ystwyth catchments in Wales (Bruen et al., 2001) showed that the microbial water quality of bathing areas was vulnerable to rainfall-related runoff from adjacent rivers in a manner that related to the patterns of catchment land use. The pioneering catchment studies in the United Kingdom in the Island of Jersey (Wyer et al., 1995) had first evidenced this, as have subsequent studies in the Staithes Beck catchment (Wyer et al., 1996a, 1998b), the Derbyshire Peak District (Tranter et al.,1996; Hunter et al., 1999), the Afon Nyfer catchment (Wyer et al., 1997), the Afon Ogwr catchment (Wyer et al., 1998a), the Holland Brook (Clacton) catchment (Wyer et al., 1999a), the River Irvine and Water of Girvan catchments (Wyer et al., 1999b), the Ribble catchment (Crowther et al., 1999b; Crowther et al. 2001) and the Windermere and Morecambe Bay catchments (Crowther et al., 1999a).

There is an argument for the 'discounting' or waiving of the microbial measurements associated with high rainfall events. This would have some resonance with the approach of the World Health Organisation that combines microbiological water quality analysis, faecal contamination risk assessment (sanitary inspection categorisation) and beach management actions (WHO 1999; Bartram and Rees 2000). Also, the United States draft Implementation Guidance for Ambient Water Quality Criteria for Bacteria (USEPA 2002) would make allowance for episodic high-flow conditions that are accompanied by high levels of indicator bacteria. A recent study showed that 60% of southern Californian shoreline examined failed water quality standards after a storm compared to only 6% during dry weather (Nobel et al. 2003); a study of Boston Harbour beaches produced a similar outcome (Coughlin and Stanley 2001). However discounting would come at a cost too, probably requiring sufficient study of responses to high rainfall events to enable accurate prediction of the potential effects, and to give appropriate public warning.

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