Bacteriological Water Quality Objective
for Bathing Beach Waters in Hong Kong

INTRODUCTION

The purpose of this paper is to brief Members on the background and rationale of the bacteriological water quality objective (WQO) for bathing beach waters in Hong Kong.

BACKGROUND

2.   Bathing beach waters may contain micro-organisms which are generally derived from sewage effluents, animal droppings and urban runoff.   Beach-goers can be exposed to these micro-organisms through direct body contact or ingestion of beach water.   These micro-organisms may, in general, cause infection-type diseases such as gastrointestinal infections or infections of the upper respiratory tract, ears, eyes, nasal cavity and skin.   The risk of humans contracting these diseases is positively correlated to the density of these micro-organisms in the water.

3.   The bacteriological WQO is promulgated under the Water Pollution Control Ordinance, Cap. 358, and has been adopted in the Technical Memorandum on Environmental Impact Assessment Process (issued under the Environmental Impact Assessment Ordinance) as a criterion for water quality impact assessment.   It is established to protect beach-goers from the risk of contracting diseases associated with swimming.   It takes the form of a limit on the density of the bacterium *E. coli*, which is a good indicator of faecal contamination of water.   A brief account on the development of the *E. coli* WQO based on human health risk is given in paragraphs 5 and 6.

4.   Beach-goers are informed of the increased health risk under the circumstances of high level of *E. coli* through a beach water quality rating system, based on water quality data obtained from the Environmental Protection Department's (EPD) routine beach water quality monitoring programme.   The system comprises two components, namely, "Annual Beach Ranking" and "Weekly Beach Grading".   The Annual Beach Ranking is used to indicate the overall water quality of the beach in a year; whereas the Weekly Beach Grading is to inform the public of the prevalent water quality.

DEVELOPMENT OF BACTERIOLOGICAL WQO FOR HONG KONG

5.   The EPD followed the recommendations of the World Health Organization (WHO) given in 1977 when the WQO was first established in the mid 1980s.   The basic component of the WHO recommendations at the time was a criterion for interim use, and the criterion was to be developed into a long-term WQO based on epidemiological studies reflecting the ambient environment and the pattern of immunity in the local population.   The then limit value[1], which was largely based on the WHO criterion, was adopted as an interim objective in Hong Kong since local epidemiological data were not available such that it was not possible to tell if the limit value could adequately predict potential health impacts on beach-goers in Hong Kong. Subsequently, the EPD, in collaboration with the Department of Community Medicine of the University of Hong Kong, initiated a series of local epidemiological studies in the late 1980s and early 1990s to gather scientific information to develop a long-term bacteriological WQO for bathing beach waters.   The findings of these and other related studies were reported in a number of scientific journals[2-6].

6.   The epidemiological studies were undertaken according to the WHO guidelines.   In the studies to develop the WQO, interviews of 39,722 beach-goers at

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[1]   The then limit value specified that the running median of *E. coli* counts of the most recent 5 consecutive samples taken 3 times a month at intervals of between 3 and 14 days during the period March to October should not exceed 1,000 per 100 mL.

[2]   Holmes PR. Research into Health Risks at Bathing Beaches in Hong Kong, J. IWEM, 1989; 3: 488-495.

[3] Cheung WHS, Chang KCK and Hung RPS. Health effects of beach water pollution in Hong Kong. Epidemiol. Infect. 1990; 105: 139-162.

[4]   Cheung WHS, Hung RPS, Chang KCK and Kleevens JWL.   Epidemiological study of beach water pollution and health-related bathing water standards in Hong Kong.   Wat. Sci. Tech. 1991; 23: 243-252.

[5]   Cheung WHS, Chang KCK and Hung RPS. Variations in microbial indicator densities in beach waters and health-related assessment of bathing water quality. Epidemiol. Infect. 1991; 106: 329-344.

[6]   Kueh CWS, Tam TY, Lee T, Wong SL, Lloyd OL, Yu ITS, Wong TW, Tam JS and Bassett DCJ. Epidemiological study of swimming associated illnesses relating to bathing beach water quality.   Wat. Sci. Tech. 1995; 31: 1-4.

nine popular and spatially distributed bathing beaches[7] were conducted followed by telephone calls to enquire about the development of illness after swimming. A high response rate at 74% was achieved. Simultaneously, intensive testing of the microbiological quality of the beach waters was carried out. *E. coli* exhibited the highest correlation with swimming-associated illnesses, and hence was found to be the best indicator of health risks among other investigated microbial indicators[8]. This enabled a quantitative relationship to be identified between *E. coli* densities and swimming-associated symptoms. Accordingly, on the advice of the then EPCOM[9], a geometric mean *E. coli* density of 180 per 100 mL, corresponding to a minor illness[10] rate of 10 in 1,000 swimmers or below, was established as the WQO for bathing beach waters in 1992. It was also established that a geometric mean *E. coli* density of 610 per 100 mL corresponding to a "Poor" ranking and an illness rate of 15 in 1,000 swimmers was considered "barely acceptable" for swimming. It is worth noting that such risk rate is still lower than the risk rate of 19 in 1,000 swimmers recommended by the United States Environmental Protection Agency[11]. Details of the local beach rating system are shown in **Table 1**.

ON-GOING DEVELOPMENT

7. Internationally, many microbial organisms are used for indicating faecal contamination of bathing beach waters, where *E. coli* and enterococci are more commonly used. With a view to keeping up with the international trend of using other microbial indicators as alternatives to *E. coli*, the EPD conducted an in-house study on the use of alternative indicators in 2001. The study covered seventeen beaches[12] which represented a full spectrum of beach water quality. The study identified strong positive correlation between *E. coli* and the other three faecal

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[7]   Bathing beaches included in the studies were Repulse Bay, Deep Water Bay, Shek O, Stanley Main, Lido, New Cafeteria, Old Cafeteria, Butterfly and Clear Water Bay 2nd.

[8]   Other investigated microbial indicators were faecal coliforms, *Klebsiella spp.*, faecal streptococci, enterococci, staphylococci, *Pseudomonas aeruginosa*, total fungi and *Candida albicans*.

[9]   The Environmental Pollution Advisory Committee (EPCOM) was the forerunner of ACE. A paper (reference no.: EPCOM 32/91) was submitted to the EPCOM to seek advice on the amendment of the interim *E. coli* WQO.

[10] Minor illnesses include instances of (i) vomiting; (ii) diarrhoea accompanied by a fever or with symptoms disabling enough for the individual to remain home, remain in bed, or seek medical advice; or (iii) stomach ache or nausea with fever.

[11] The risk rate is used in the United States Environmental Protection Agency's Final Rule on "Water Quality Standards for Coastal and Great Lakes Recreation Waters", 16 November, 2004.

[12] Beaches included in the 2001 study were Approach, Big Wave Bay, Butterfly, Clear Water Bay 2nd, Deep Water Bay, Gemini, Golden, Hoi Mei, Hung Shing Yeh, Kadoorie, Lido, Repulse Bay, Shek O, Silver Mine Bay, Silverstrand, Stanley Main and Ting Kau.

indicators: faecal streptococci, enterococci and *Clostridium perfringens*. **Figure 1** shows that the level of enterococci in beach waters was the lowest of the organisms investigated; whereas *E. coli* had the highest density and the widest distribution (i.e. *E. coli* was present in more water samples than the other organisms). *E. coli* was found to be more sensitive in indicating sewage pollution, and therefore an appropriate indicator for local waters.

8.   In 2003, WHO promulgated a new set of guidelines in which enterococci was recommended as an indicator for microbiological quality of marine beach waters, but at the same time reiterated that jurisdictions need to develop their own WQO based on local data and socially accepted human health risk. In view of this and to check the reproducibility of the work done in 2001, the EPD conducted another study covering three selected beaches[13] in 2006/08, again representing beaches of typically good, poor and very poor water quality. The investigation is still on-going but the results so far support the earlier findings that *E. coli* is the most sensitive and appropriate microbial indicator for beach waters in Hong Kong. However, we are open to new possibilities, and in this regard we shall continue to watch closely new developments in the scientific community and practices of other jurisdictions (especially those in the sub-tropical region where Hong Kong is located) and decide if there are convincing arguments for a change.

CONCLUSION

9.   Members are invited to note the information set out in this paper.

Environmental Protection Department
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[13] Beaches included in the 2006/08 study were Deep Water Bay, Lido and Gemini.

Table 1 : Minor Illness Rate associated with *E. coli* counts in Bathing Beach Waters and Hong Kong's Annual Beach Ranking System and Weekly Beach Grading System

Annual Ranking		Weekly Grading		Minor Illness Rate (cases per 1,000 swimmers)	WQO Compliance
Beach Rank	*E. coli* counts per 100 mL [a]	Beach Grade	*E. coli* counts per 100 mL [b]		
Good	24	1	24	Undetectable	Compliant
Fair	25 – 180	2	25 – 180	< 10	Compliant
Poor	181 – 610	3	181 – 610	11 – 15	Non-compliant
Very Poor	> 610	4 [c]	> 610 or the last reading > 1,600 [d]	> 15	Non-compliant

Notes:

a. The *E. coli* concentration is the geometric mean of all data collected during the bathing season (from March to October).

b. Unless otherwise specified, the *E. coli* concentration is the running geometric mean of the five most recent sampling occasions.

c. The EPD advises closing a beach for swimming when the geometric mean *E. coli* counts of the 5 most recent sampling occasions exceeds 610 per 100 mL or when the count of the last sampling occasion exceeds 1,600 per 100 mL.   When sudden deterioration of beach water is detected, the EPD will activate pollution investigation and control procedures as appropriate, which include identification of pollution source and emergency response actions to alleviate the pollution impact.   Water quality monitoring frequency will be intensified until the bacterial concentration returns to the normal level.

d. The triggering limit of 1,600 *E. coli* counts/100 mL was derived on the basis of the local epidemiological studies conducted in the late 1980s and early 1990s, and the statistical method recommended by the United States Environmental Protection Agency.

Figure 1 :   Levels of Bacterial Indicators in Beach Water samples collected in an EPD's Study in 2001