市 政 署
INSTITUTO PARA OS ASSUNTOS MUNICIPAIS

Macao Beach Water Quality Monitoring Report 2024

Laboratory Division of
Municipal Affairs Bureau

Table of Contents

I. Introduction

To safeguard the health of swimmers and understand the water quality of beaches on a continuous basis, the Laboratory Division of the Municipal Affairs Bureau of Macao carries out regular monitoring of the water quality of the two public beaches in Macao, namely Hac Sá Beach and Cheoc Van Beach.

1. Beach Water Quality Monitoring Programme

The three water quality monitoring points at Hac Sá Beach are located separately in the waters facing the three lifeguard stands, while the two monitoring points at Cheoc Van Beach are located close to the two ends of the rope net in the swimming area.

Three monitoring points at Hac Sá Beach

Two monitoring points at Cheoc Van Beach

Upon arrival at the beaches, the sample collectors first observe and pay attention to the environmental conditions on site, such as weather changes and state of the sea, including the appearance of red tide and creatures like jellyfish. Then they carry out water sample collection work. After carrying out on-site tests of pH value, dissolved oxygen and others, the sample collectors send the samples to the laboratory, which are subject to tests of multiple bacteriological, physical and chemical or biological parameters in accordance with the monitoring programme.

In view of the large number of users of the beaches during the swimming season (from May to October each year), the monitoring of water quality is strengthened during the period. Samples are collected once per week during the swimming season and once per month during non-swimming seasons. Throughout the year, regular sample collection was carried out 34 times at Hac Sá Beach and 32 times at Cheoc Van Beach. A total of 161 water samples were collected from the two beaches and 3,457 tests were conducted for over 40 parameters.

2. Assessment of Beach Water Quality

The beach water quality is assessed on the basis of the geometric mean of *Escherichia coli* (*E. coli*) count in the five most recent water samples. When the geometric mean of *E. coli* count in the five most recent samples exceeds 610 CFU/100 mL (>610 CFU/100 mL), or the *E. coli* in the most recent water sample collected exceeds 1600 CFU/100 mL (>1600 CFU/100 mL), the beach water quality is assessed as “fail”.

According to all collected results of geometric mean of *E. coli* during the whole year, with reference to the annual ranking system of beach water quality of the Environmental Protection Department of Hong Kong which classifies beach water quality into four ranks, namely “Good”, “Fair”, “Poor” and “Very Poor”, assessment on the annual conditions of water quality of beaches and provision of information about long-term trends of beach water quality can be made.

Annual Ranking System of Beach Water Quality	
Rank	*E. coli* count per 100 mL
Good	≤24
Fair	25 - 180
Poor	181 - 610
Very poor	> 610

3. Rainfall Effect on Beach Water Quality

The beach water quality may deteriorate rapidly during or after heavy rain, and it usually resumes normal in around three days. Therefore, swimming in beaches should be avoided as far as possible during heavy rain or within three days thereafter.

4. Summary of Annual Beach Water Quality

This report makes an analysis and assessment of the water quality of the two beaches in Macao on the basis of the monitoring results of major parameters. The bases of assessment are as follows:

- Bacteriological parameters – With reference to the beach water quality objective of the Environmental Protection Department of Hong Kong.
- Physical and chemical parameters – With reference to the "Sea Water Quality Standard" of China (GB 3097-1997) Class II water quality standard.

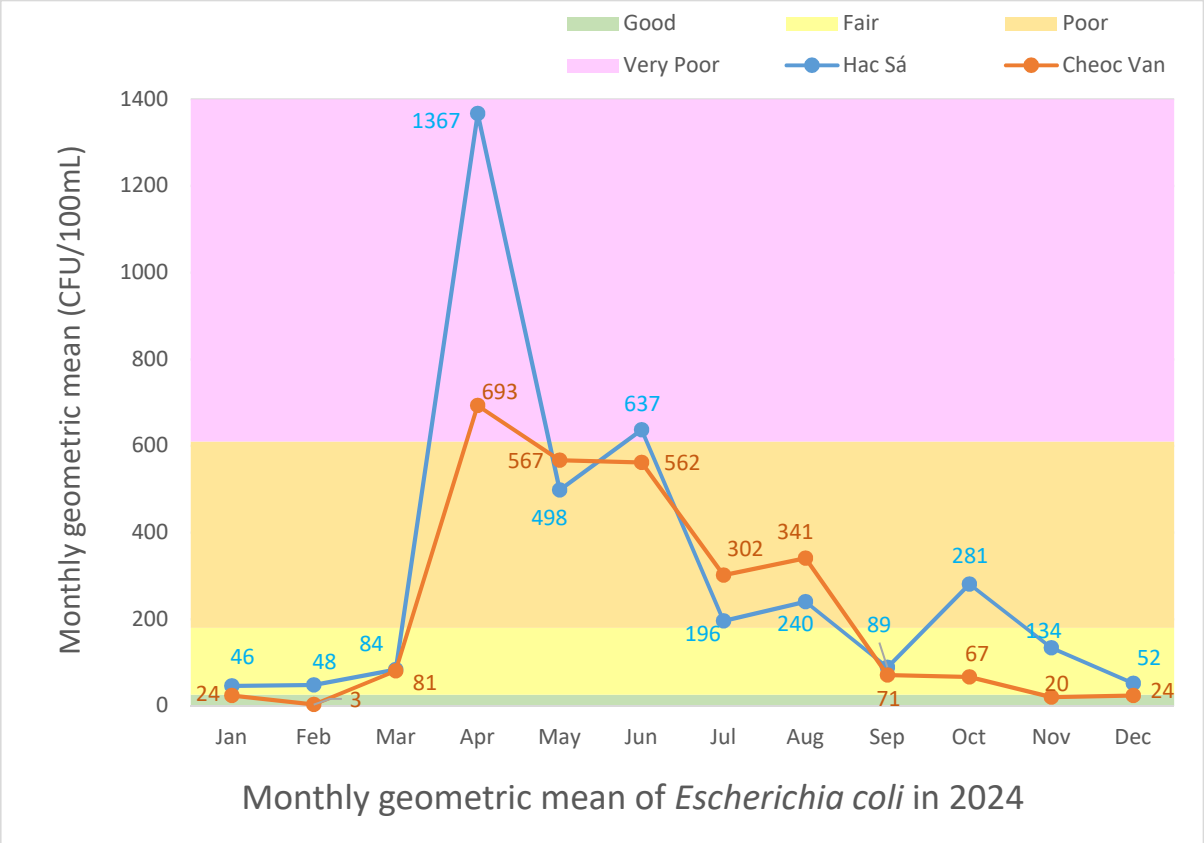
II. Monitoring Results of Bacteriological Parameters

1. Bacteriological Parameters

The bacteriological monitoring items include *Escherichia coli* (*E. coli*) and *Vibrio cholerae* (serogroups O1 and O139).

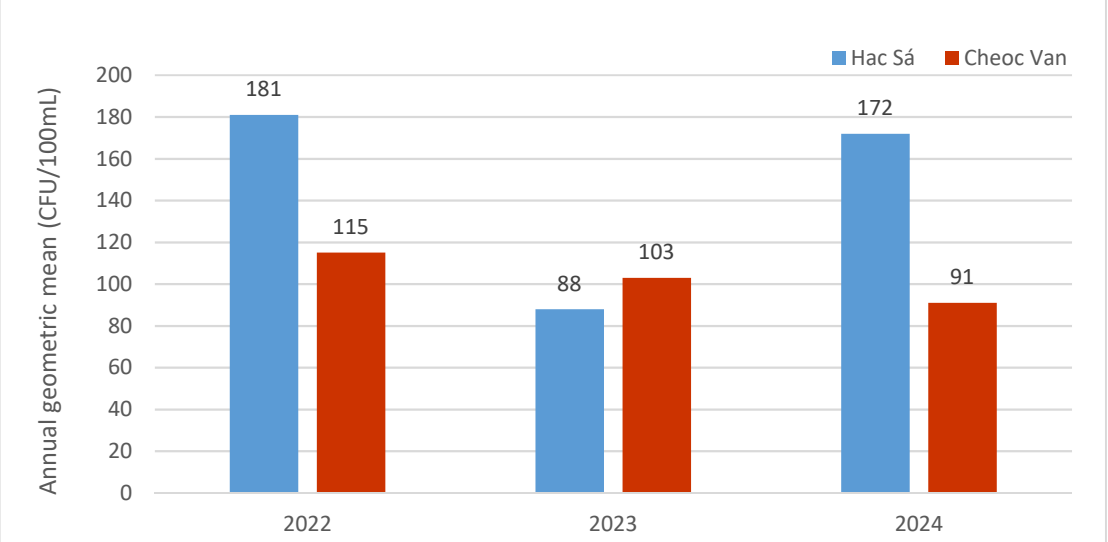
(1) *Escherichia coli* (*E. coli*)

The monthly geometric means of *E. coli* of Hac Sá Beach and Cheoc Van Beach were the highest in April throughout the year, with results of 1,367 CFU/100 mL and 693 CFU/100 mL respectively. The monthly geometric mean of *E. coli* of Hac Sá Beach was the lowest in January throughout the year, with a result of 46 CFU/100 mL; the monthly geometric mean of *E. coli* of Cheoc Van Beach was the lowest in February throughout the year, with a result of 3 CFU/100 mL.



Monthly geometric mean of *Escherichia coli* in 2024

The number of fails of the two beaches was more than that of 2023. Samples were collected from Hac Sá Beach for a total of 33 times throughout the year and the water quality failed 10 times, with a pass rate of 69.7%; samples were collected from Cheoc Van Beach for a total of 31 times throughout the year and the water quality failed 8 times, with a pass rate of 74.2%. The annual geometric means of *E. coli* of Hac Sá Beach was higher than the one of last year, whereas the annual geometric means of *E. coli* of Cheoc Van Beach was lower than the one of last year.



Annual geometric mean of *Escherichia coli* of the two beaches from 2022 to 2024

(2) *Vibrio cholerae* (serogroups O1 and O139)

Vibrio cholerae (serogroups O1 and O139) was not detected at the two beaches.

2. Bacteriological Ranking of Water Quality

On the basis of *E.coli* test results and with reference to the beach ranking system of the Environmental Protection Department of Hong Kong, Hac Sá Beach and Cheoc Van Beach were ranked “Very Poor” for two months and one month respectively. There were four months that both beaches were ranked “Poor”, and six months and three months that they were ranked “Fair” respectively. Cheoc Van Beach reached the “Good” rank for four months.

III. Monitoring Results of Physical and Chemical Parameters

The monitoring items of physical and chemical parameters include four types, namely physical parameters, organic pollution parameters, nutrient pollution parameters and heavy metal pollution parameters, while the eutrophication index and the comprehensive physical and chemical water quality assessment index are also calculated.

1. Physical Parameters

Physical parameters (water temperature, conductivity, salinity, turbidity and pH):

- The water temperature of the samples collected from the two beaches was between 18.8℃ and 33.5℃
- The conductivity of the samples collected from the two beaches was between 3.4 mS/cm and 43.8 mS/cm, and the salinity was between 1.7 psu and 30.4 psu. The results of both parameters were relatively dispersed. The mean values of conductivity and salinity showed a continuous year-on-year rise which was estimated to be related to low rainfall.
- Turbidity is the most direct factor affecting the senses of beach users. The annual turbidity means of Hac Sá Beach and Cheoc Van Beach were 61 NTU and 59 NTU respectively, both similar to the annual turbidity means of 2023 (59 NTU and 58 NTU for Hac Sá Beach and Cheoc Van Beach respectively). It was estimated that the turbidity was mainly affected by the comparatively large suspended substances in beach water.
- Certain pH value results failed to comply with the “Sea Water Quality Standard” for Class II (7.8 – 8.5). The pH of the year of Hac Sá Beach were lower than 7.8 for twice in May and August, whereas the pH of Cheoc Van Beach were lower than 7.8 for thirteen times from March to June and from August to December. The fall in pH of water was estimated to be related to organisms being brought to coastal areas.

2. Organic Pollution Parameters

The organic pollution parameters include dissolved oxygen, permanganate index (chemical oxygen demand) and five-day biochemical oxygen demand. They are all important indicators of the severity of organic pollution of the water and its ability to achieve self-cleaning effect through self-oxidation process.

- The dissolved oxygen of the two beaches maintained at relatively high level and all the results reached the "Sea Water Quality Standard" for Class II (>5 mg/L). The results of Hac Sá Beach was lower than 5.0 mg/L in August, a decrease in dissolved oxygen estimated to result from higher water temperature.
- The permanganate indexes (chemical oxygen demand) of the two beaches basically reached the "Sea Water Quality Standard" for Class II (≤3 mg/L). Throughout the year, the permanganate index of Hac Sá Beach exceeded 3 mg/L twice, which were 3.97 mg/L in May and 3.03 mg/L in June, same as the results in 2023. The permanganate index of Cheoc Van Beach exceeded 3 mg/L once in September at 3.35 mg/L. The mean values of the results of the two beaches were 2.06 mg/L for Hac Sá Beach and 1.73 mg/L for Cheoc Van Beach respectively, showing a slight decrease compared to the results in 2023.
- Five-day biochemical oxygen demand: The test results of both beaches complied with the "Sea Water Quality Standard" for Class II (≤3 mg/L) throughout the year; the test results of five-day biochemical oxygen demand of Hac Sá Beach exceeded 2.0 mg/L in August and September at 2.3 mg/L and 2.4 mg/L, whereas the test results of five-day biochemical oxygen demand of Cheoc Van Beach exceeded 2.0 mg/L once in September at 2.4 mg/L. The test results indicated that the levels of organic pollution of both beaches were higher in the swimming season than in other months.

3. Nutrient Pollution Parameters

The nutrient pollution parameters include unionised ammonia, inorganic nitrogen and activated phosphate.

- The test results of unionised ammonia of Hac Sá Beach and Cheoc Van Beach complied with the "Sea Water Quality Standard" for Class II (≤0.020 mg/L) throughout the year, with the mean values of the two beaches being 0.002 mg/L and 0.003 mg/L respectively. The test results indicated that there was no obvious difference in the pollution caused by unionised ammonia in 2024 compared to those of 2023.
- The components of inorganic nitrogen include ammonium nitrogen and total oxidised nitrogen. Due to the high dissolved oxygen content in the water of the two beaches, the nitrification process of nitrogen pollutants in water was favoured, making total oxidised nitrogen the major component of inorganic nitrogen. The mean values of the results of the Hac Sá Beach and Cheoc Van Beach were 1.11 mg/L and 1.07 mg/L respectively, similar to the results of 1.00 mg/L (Hac Sá Beach) and 1.09 mg/L (Cheoc Van Beach) in 2023. The results of inorganic nitrogen of the year continued to exceed the "Sea Water Quality Standard" for Class II (≤0.30 mg/L).
- Throughout the year, 67% of the results of labile phosphate of the two beaches exceeded the "Sea Water Quality Standard" for Class II (≤0.030 mg/L), indicating a decrease compared to the results of 2023. The test results ranged between the limit of detection (0.009 mg/L) of the analysis method and 0.050 mg/L, indicating that phosphorus pollution was still found at the two beaches.

4. Heavy Metal Pollution Parameters

The heavy metal pollution parameters include arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium and zinc, a total of nine items. The lead test results of both beaches in the year exceeded the "Sea Water Quality Standard" for Class II for twice respectively in 2024, whereas the results of both beaches throughout 2024 complied with the standard.

The following table shows the mean values of results of various heavy metals in the recent two years for comparison.

Comparison table of Mean Values of Heavy Metal Pollution Parameters

Mean (mg/L) / Parameter (limit) (GB 3097-1997 Class II)	Cheoc Van Beach		Hac Sá Beach	
	2023	2024	2023	2024
Arsenic (≤0.030 mg/L)	<0.004	<0.004	<0.004	<0.004
Cadmium (≤0.005 mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
Chromium (≤0.10 mg/L)	<0.004	<0.004	<0.004	<0.004
Copper (≤0.010 mg/L)	<0.004	<0.004	<0.004	<0.004
Mercury (≤0.0002 mg/L)	0.00050	<0.00010	<0.00010	<0.00010
Nickel (≤0.010 mg/L)	<0.004	<0.004	<0.004	<0.004
Lead (≤0.005 mg/L)	<0.004	<0.004	<0.004	<0.004
Selenium (≤0.020 mg/L)	<0.004	<0.004	<0.004	<0.004
Zinc (≤0.050 mg/L)	<0.020	<0.020	<0.020	<0.020

5. Eutrophication Index

The eutrophication index is used for evaluation of the degree of eutrophication of the sea. As a reference indicator of organic and nutrient pollution of sea water, it is calculated by permanganate index (chemical oxygen demand), inorganic nitrogen concentration and labile phosphate concentration. The larger the index, the more severe is the eutrophication of the water.

As the test results of permanganate and labile phosphate decreased slightly, the eutrophication index slightly decreased compared to that of 2023. It can be seen from the test results that the eutrophication index of Hac Sá Beach and Cheoc Van Beach ranged from 3 to 31 with the annual mean values of the two beaches at 17 and 14 respectively. The results indicated that the nearby water was still subject to pollution caused by excessive nitrogen, phosphorus and other nutrients. Eutrophication was still severe in the water of the two beaches.

6. Comprehensive Physical and Chemical Assessment of Water Quality

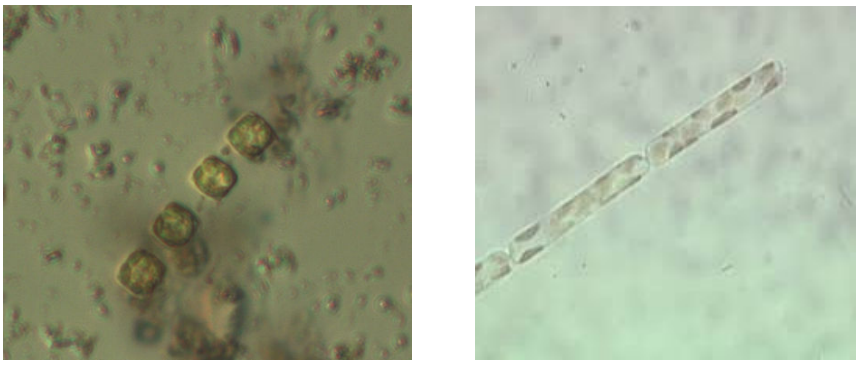
The index of comprehensive physical and chemical assessment of water quality is determined by statistical analysis of the 16 items of the "Sea Water Quality Standard", and it is a comprehensive embodiment of the annual water quality of the two beaches. In order to differentiate the impacts of non-metal and metal pollutants on the beach water quality, the comprehensive assessment is divided into non-metal assessment (7 non-metals: pH value, dissolved oxygen, permanganate index, five-day biochemical oxygen demand, unionised ammonia, inorganic nitrogen and labile phosphate) and heavy metal assessment (9 heavy metals: arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium and zinc). The index of comprehensive physical and chemical assessment is calculated through the two above-mentioned assessments to have an comprehensive assessment of the impact of the 16 items on the beach water quality. The larger the assessment index, the more severe is the pollution.

- Non-metal assessment: Both beaches showed a slight decrease in the test values of permanganate and labile phosphate, resulting in a lower non-metal assessment index than that of 2023. The non-metal assessment indexes of Hac Sá Beach and Cheoc Van Beach were 0.92 and 0.95 respectively, showing the unfavourable conditions of the non-metal assessment of the two beaches.
- Heavy metal assessment: The heavy metal assessment indexes of Hac Sá Beach and Cheoc Van Beach were both 0.04 and 0.02 respectively, both lower than those of 2023 due to the fact that the lead test results of both beaches exceeded the "Sea Water Quality Standard" for Class II for twice respectively in 2023, while the results of both beaches reached the standard throughout 2024. The content of heavy metal of both beaches was at a relatively low level. The overall metal pollution was relatively minor.
- Comprehensive physical and chemical assessment: The heavy metal assessment indexes and non-heavy metal assessment indexes of both beaches lower than those of 2023 resulted in an decrease in the comprehensive assessment index. The overall assessement indexes of the two beaches maintained at medium level for years.

IV. Monitoring Results of Biological Parameters

1. Algae

- Qualitative analysis: The most common dominant algae of the two beaches was *Skeletonema costatum*, followed by *Thalassiosira* as the major type. Among the 27 tests at Hac Sá Beach throughout the year, *Skeletonema costatum* was detected for 14 times, being the most frequently occurring algae. The next frequently occurring algae was *Thalassiosira*, being detected for 8 times. Among the 27 tests at Cheoc Van Beach throughout the year, *Skeletonema costatum* was also the most frequently occurring algae, being detected for 10 times and the next frequently occurring algae was *Thalassiosira*, being detected for 8 times.
- Quantitative analysis: The annual geometric mean of algae at Hac Sá Beach was 307 Natural units/mL, representing a decrease compared to 490 Natural units/mL of 2023; the annual geometric mean of algae at Cheoc Van Beach was 270 Natural units/mL, representing a decrease compared to 340 Natural units/mL of 2023.
- Red tide: Two red tides occurred at Hac Sá Beach and Cheoc Van Beach in Macao respectively in January and December. The red tides in January were mainly formed by *Phaeocystis*, whereas those in December were mainly formed by *Dactyliosolen*.



Thalassiosira (left) and *Dactyliosolen* (right) magnified 400 times under a microscope

2. Other Creatures

- No other creature was observed.

V. Summary

1. Classifying the annual geometric mean values of *E. coli* of the beaches, the water quality of the two beaches was ranked “Fair” for the year of 2024.

2. The eutrophication indexes of the two beaches showed a slight decrease from 2023.

3. The comprehensive physical and chemical assessment indexes of the two beaches maintained at medium level.

4. The annual geometric means of algae of both beaches showed a decrease. The most common dominant algae of the two beaches throughout the year were mainly *Skeletonema costatum* and *Thalassiosira*. Two red tides occurred at Hac Sá Beach and Cheoc Van Beach respectively, mainly formed by *Phaeocystis* and *Dactyliosolen* respectively.