



Macao Beach Water Quality Monitoring Report 2023

**Laboratory Division of
Municipal Affairs Bureau**

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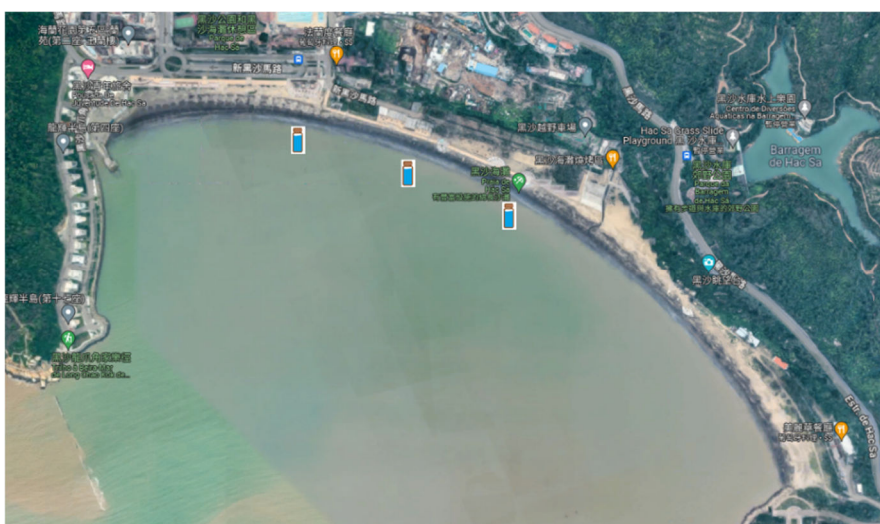
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I. Introduction

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 carry out water sample collection. After carrying out on-site tests of pH value, dissolved oxygen and others, the sample collectors send the samples to the laboratory, which are then 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, sample collection was carried out 29 times at both Hac Sá Beach and Cheoc Van Beach. A total of 145 water samples were collected from the two beaches and 3,518 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 categories, 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	<i>E. coli</i> 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 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 (GB3097-1997) Class II water quality standard.

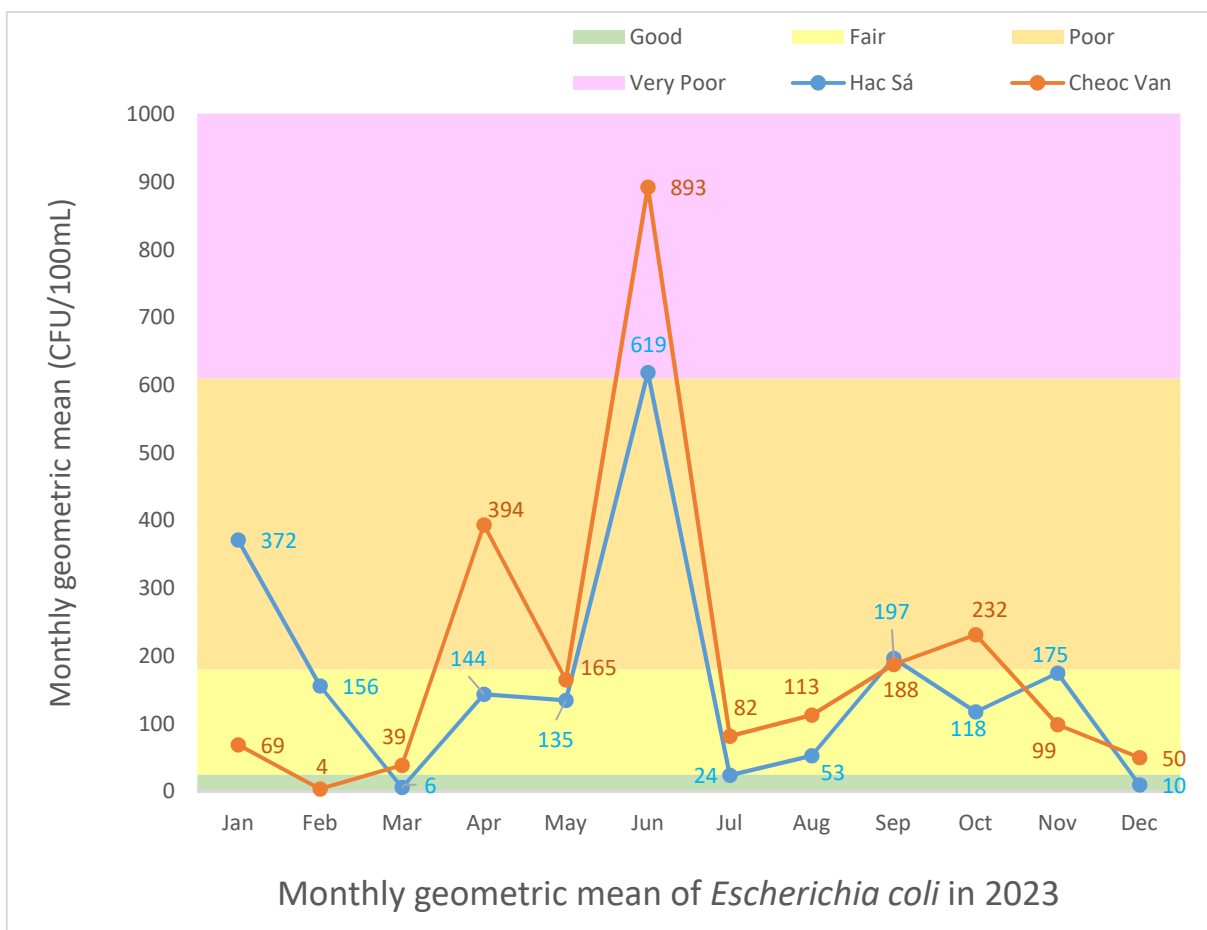
II. Monitoring Results of Bacteriological Parameters

1. Bacteriological Parameters

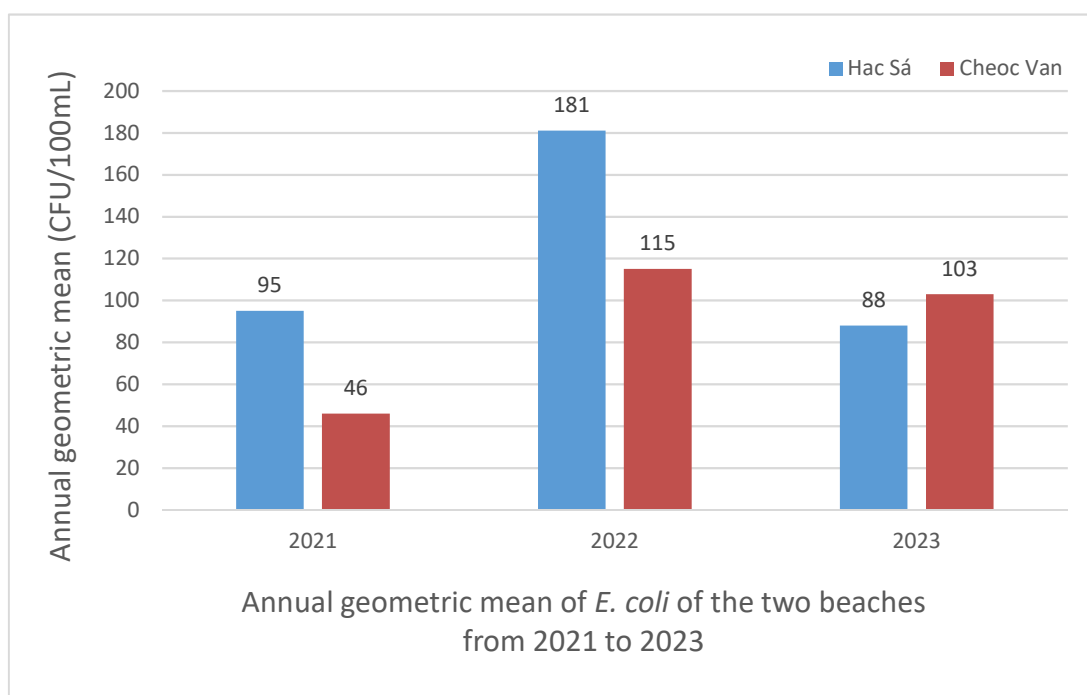
The bacteriological monitoring items include *Escherichia coli* (*E. coli*) and *Vibrio cholera* (serogroups O1 and O139).

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

The monthly geometric means of *E. coli* of Hac Sá Beach and Cheoc Van Beach were the highest in June throughout the year, with results of 619 CFU/100 mL and 893 CFU/100 mL respectively. The monthly geometric mean of *E. coli* of Hac Sá Beach was the lowest in March throughout the year, with a result of 6 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 4 CFU/100mL.



The number of failures of Hac Sá Beach was less than that of 2022. Samples were collected from Hac Sá Beach for a total of 28 times throughout the year and the water quality failed twice, with a pass rate of 92.9%; samples were collected from Cheoc Van Beach for a total of 29 times throughout the year and the water quality failed 3 times, with a pass rate of 89.7%. The annual geometric means of *E. coli* of the two beaches were lower than those of 2022.



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

Vibrio cholera (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, both beaches were both ranked as “Very Poor” for one month. There were two months and three months that Hac Sá Beach and Cheoc Van Beach were ranked “Poor” respectively, and six months and seven months that they were ranked “Fair” respectively. Hac Sá Beach reached the “Good” ranking for three months; Cheoc Van Beach reached the “Good” ranking for 1 month.

III. Monitoring Results of Physical and Chemical Parameters

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

1. Physical Parameters

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

- The water temperature of the samples collected from the two beaches was between 18°C and 32.6 °C.
- The electrical conductivity of the samples collected from the two beaches was between 3.6 mS/cm and 47.1 mS/cm, and the salinity was between 1.6 psu and 28.9 psu. The results of both parameters were relatively dispersed. The mean values of electrical 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 sensation of beach users. The annual turbidity means of Hac Sá Beach and Cheoc Van Beach were 59 NTU and 58 NTU respectively, both were higher than those of 2022 (56 NTU and 50 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.
- All the pH values of the year of Hac Sá Beach met the national seawater standards of Class II (7.8 – 8.5), whereas the pH of Cheoc Van Beach was lower than 7.8 in April and September. The fall in pH of water was estimated to be related to the organic substance which were 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 met the national seawater standards of Class II (>5 mg/L). The results of Hac Sá Beach were lower than 5.0 mg/L in August, a decrease in dissolved oxygen resulting from higher water temperature.
- The permanganate index (chemical oxygen demand) basically complied with the national seawater standards of Class II (≤ 3 mg/L). Throughout the year, the permanganate index of Hac Sá Beach exceeded 3 mg/L twice, which were 3.07 mg/L in June and 4.07 mg/L in July, one time more compared to the results in 2022. The permanganate index of Cheoc Van Beach exceeded 3 mg/L once in July which was 3.45 mg/L. The mean values of the results of the two beaches were 2.32 mg/L (Hac Sá Beach) and 1.96 mg/L (Cheoc Van Beach), showing a slight increase compared to the results of 2022.
- Five-day biochemical oxygen demand: The test results of Hac Sá Beach complied with the national seawater standards of Class II (≤ 3 mg/L) throughout the year; the test results of five-day biochemical oxygen demand of Cheoc Van Beach exceeded 3 mg/L once in February at 4.2 mg/L. The amount of organic substances of both beaches exceeded 2.0 mg/L in August and September of 2022, but did not exceed 2.0 mg/L in the same period in 2023. The results indicated that the level of organic pollution in water of both beaches had improved compared to 2022.

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 national seawater standards of Class II (≤ 0.020 mg/L), with the mean values of the two beaches being 0.005 mg/L and 0.004 mg/L respectively. The test results indicated that there was no obvious difference in the pollution caused by unionised ammonia in 2023 compared to those of 2022.
- The components of inorganic nitrogen include ammoniacal nitrogen and total oxidised nitrogen. Due to the high dissolved oxygen level 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 two beaches were 1.00 mg/L (Hac Sá Beach) and 1.09 mg/L (Cheoc Van Beach), a slight increase compared to the results of 0.98 mg/L (Hac Sá Beach) and 1.01 mg/L (Cheoc Van Beach) in 2022. The results of inorganic nitrogen of the year continued to exceed the national seawater standards of Class II (≤ 0.30 mg/L).
- Throughout the year, 72% of the results of activated phosphate of the two beaches exceeded the national seawater standards of Class II (≤ 0.030 mg/L), indicating an increase compared to the results of 2022. The test results ranged between the limit of detection (0.009 mg/L) of the analytical method and 0.050 mg/L. The phosphorus pollution of the year was found at the two beaches in all the months throughout the year.

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 national seawater standards of Class II twice, and the number of exceedances increased compared with 2022. In regard to copper and mercury test results, both beaches complied with the standard in the year, whereas there was once in 2022 that the test results of Cheoc Van Beach exceeded the standard. The test results of other

heavy metals did not exceed 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 Parameter (limit) (GB 3097-97 Class II)	Cheoc Van Beach		Hac Sá Beach	
	2022	2023	2022	2023
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 with permanganate index (chemical oxygen demand), inorganic nitrogen concentration and activated phosphate concentration. The larger the index, the more severe is the eutrophication of the water.

As the amount of inorganic nitrogen and activated phosphate of the two beaches

increase slightly, the eutrophication index was also higher than that of 2022. It can be seen from the test results that the eutrophication index of Hac Sá Beach and Cheoc Van Beach ranged from 1 to 40 with the annual mean values of the two beaches at 14 and 15 respectively, showing a slight increase compared to the annual mean values of 2022. 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 comprehensively reflect 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, dissolved oxygen, permanganate index, five-day biochemical oxygen demand, unionised ammonia, inorganic nitrogen and activated 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 by 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 index, the more severe is the pollution.

- Non-metal assessment: Both beaches showed a slight increase in the test values of inorganic nitrogen and activated phosphate, resulting in a higher non-metal assessment index than that of 2022. The non-metal assessment indexes of Hac Sá Beach and Cheoc Van Beach were 0.93 and 1.03 respectively, showing an 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 0.06. The heavy metal assessment index of Hac Sá Beach

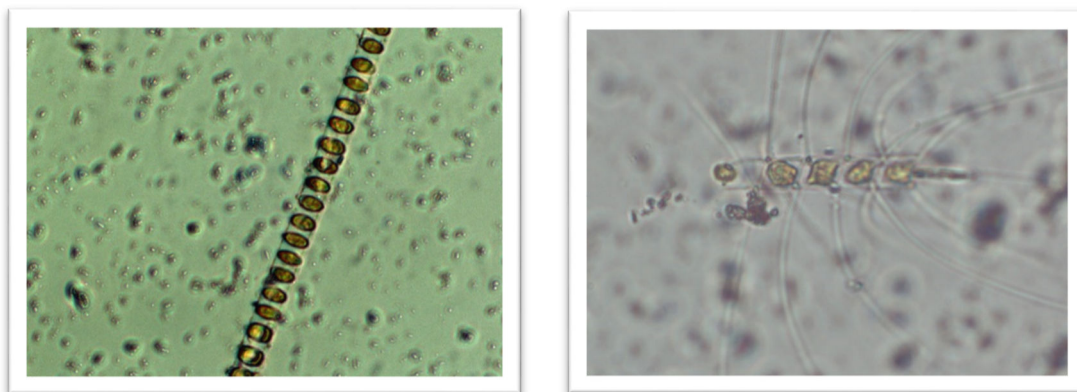
was lower than that of 2022 due to the slight decrease in the amount of arsenic, chromium, copper, manganese, nickel and other metals compared to those of 2022. All heavy metal test results of Cheoc Van Beach met the national seawater standards of Class II, among which the test results of arsenic, chromium, nickel, mercury and other heavy metals were slightly lower than those of 2022, resulting in a lower heavy metal assessment index than that of 2022. The amount of heavy metal was at a relatively low level for both beaches. The overall metal pollution was relatively minor.

- Comprehensive physical and chemical assessment: The overall assessment index of Hac Sá Beach did not change much compared to that of 2022. The heavy metal assessment index of Cheoc Van Beach was lower than that of 2022, resulted in a decline in the comprehensive assessment index. The overall assessment 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 alga of the two beaches was *Skeletonema costatum*, followed by *Chaetoceros* and *Thalassionema*. Among the 27 tests at Hac Sá Beach throughout the year, *Skeletonema costatum* was detected for 13 times, being the most frequently occurring algae. The next frequently occurring alga was *Chaetoceros*, being detected for 8 times. Among the 26 tests at Cheoc Van Beach throughout the year, *Skeletonema costatum* and *Chaetoceros* were also the most frequently occurring algae, detected for 13 times and 10 times respectively.
- Quantitative analysis: The annual geometric mean of algae at Hac Sá Beach was 490 Natural units/mL, representing an obvious increase compared to that of 2022; the annual geometric mean of algae at Cheoc Van Beach was 340 Natural units/mL, representing a slight decrease compared to that of 2022.
- Red tide: A red tide occurred at Hac Sá Beach in February, which was mainly caused by *Noctiluca scintillans*. No red tide occurred at Cheoc Van Beach for the year.



Skeletonema costatum (left) and *Chaetoceros* (right) magnified 400 times under a microscope

2. Other Creatures

- No other creature was observed.

V. Summary

1. According to the annual geometric mean values of *E. coli* of the beaches, the water quality of the two beaches was ranked “Fair” for the year.
2. The eutrophication indexes of the two beaches showed a slight increase from 2022.
3. The comprehensive physical and chemical assessment indexes of the two beaches maintained at medium level.
4. The annual geometric means of algae of Hac Sá Beach showed an obvious increase, while the means of Cheoc Van Beach showed a slight decrease. The most common dominant algae of the two beaches throughout the year were mainly *Skeletonema costatum* and *Chaetoceros*. Red tide occurred once at Hac Sá Beach in February.