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Baseline of Pollution of Heavy Metals and Physico-chemical Parameters in Surface Sediments from Quanzhou Bay, China, in 2006-2007

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Abstract

According to the monitoring results of the near-shore sediments of Quanzhou Bay in 2006-2007, we analyzed the near-shore depositional environmental quality of Quanzhou Bay and assessed it by the single-factor evaluation on the basis of corresponding standards of local marine functional areas. The results showed that the sediments from the inner part of Quanzhou Bay were polluted more seriously than that of the open part, which might be due to the increasing human activities in coastal areas. The main exceeding standard items are petroleum, Cu, Zn and Pb. In additions, the pollutions caused by sulfide and Cr are different in different regions. The contents of Hg and As are basically in according with the sedimentary quality standards of the corresponding marine functional areas. According the evaluating results, we also provided the corresponding measures to control the pollutions in sedimentary environment of Quanzhou Bay.

Keywords: Baseline; Heavy metals; Physico-chemical parameters; Pollution; Environmental evaluation; Surface sediment; Quanzhou Bay; Meatures

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1. Introduction

Quanzhou Bay, which located in the southeast of Fujian Province, China, is an east open-type bay. It has a wide mouth and shallow water area, with a total area of 128.18 km^2 [1].

The terrestrial substances are always transported from land to the coastal sea area via bay or estuary, which is also most strongly affected by man-conducted activities [2]. With the rapid economic development of the coastal area of Quanzhou Bay, there are increasing contents of land-based pollutions entering into the seawater. Then, most of persistent pollutants in the seawater, including heavy metals, will be quickly transferred to solid phase by the physical material deposition and chemical scavenging. As a consequence, coastal sediment is a cumulative sink of water contaminants [3].

As a result, analyzing the pollutants of the near-shore sediments is an important means to track the pollution effect caused by human beings [3]. In order to master the current pollution situation of sediments from Quanzhou Bay and use the marine resources rationally, we study the characteristics of the pollutants in the near-shore sediments of Quanzhou Bay, including the contents and distributions. On this basis, we also compare the sedimentary environment of Quanzhou Bay with the other bays in Fujian Province. All of these will provide the important theoretical basis to prevent various pollutions in water and sediments and protect the estuarine environments.

2. Sampling and Methods

2.1 Survey Stations

Investigating the sediments of Quanzhou Bay, there are nine stations in the inner bay and eight stations in the open bay. The specific stations are listed in Fig. 1.

2.2 Methods

The sediment monitoring items are Cu, Zn, Cd, Pb, Cr, Hg, As, organic carbons (OC), petroleum and sulfide. The water quality monitoring methods refer to the rules of “Chinese Marine Monitoring” (GB17378-2007) [4]. We will use the single factor index [5] method to evaluate the water quality. Each monitoring project was assessed on the implementation of the first class standards in the “Marine Sediment Quality Standard” (GB18668-2002) [6].

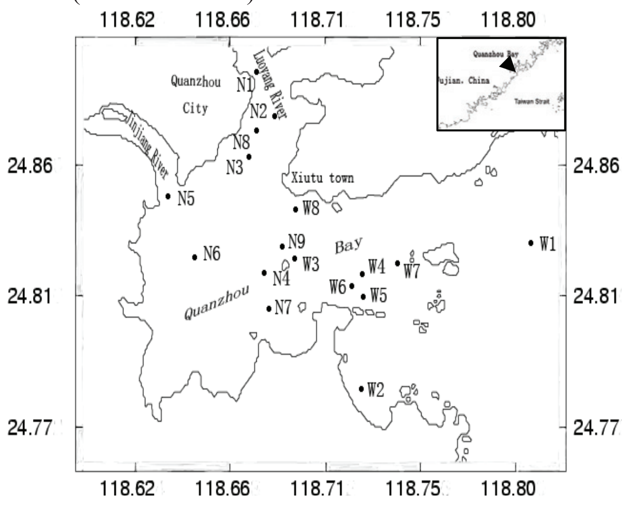

Figure1. Survey Stations of Quanzhou Bay, China

3. Results

3.1 Monitoring Results

a) Inner Quanzhou Bay

In the sediments of inner Quanzhou Bay, the OC value was in the range of 0.1%~1.3% (averaged in 0.7%). The sulfide value was in the range of 2.6~309.6 $\mu g \cdot g^{-1}$ (averaged in 133.9 $\mu g \cdot g^{-1}$). The petroleum value was in the range of 10.0~874.0 $\mu g \cdot g^{-1}$ (averaged in 384.7$\mu g \cdot g^{-1}$). The Cu value was in the range of 10.3~42.8 $\mu g \cdot g^{-1}$ (averaged in 22.6 $\mu g \cdot g^{-1}$). The Zn value was in the range of 34.4~223.0 $\mu g \cdot g^{-1}$ (averaged in 93.4 $\mu g \cdot g^{-1}$). The Pb value was in the range of 12.9~191.0 μg·g-1 (averaged in 60.6 μg·g-1). The Cr value was in the range of 5.8~21.6 $\mu g \cdot g^{-1}$ (averaged in 11.4 $\mu g \cdot g^{-1}$). The Cd value was in the range of 0.11~0.19 $\mu g \cdot g^{-1}$ (averaged in 0.15 $\mu g \cdot g^{-1}$). The Hg value was in the range of 0.009~0.09 $\mu g \cdot g^{-1}$ (averaged in 0.05 $\mu g \cdot g^{-1}$). The As value was in the range of 1.8~7.4 $\mu g \cdot g^{-1}$ (averaged in 4.7 $\mu g \cdot g^{-1}$).

b) Open Quanzhou Bay

In the sediments of open Quanzhou Bay, the OC value was in the range of 0.5%~1.1% (averaged in 0.7%). The sulfide value was in the range of 9.0~249.6 $\mu g \cdot g^{-1}$ (averaged in 138.0 $\mu g \cdot g^{-1}$). The petroleum value was in the range of 4.6~568.0 $\mu g \cdot g^{-1}$ (averaged in 224.9 $\mu g \cdot g^{-1}$). The Cu value was in the range of 10.2~42.3 $\mu g \cdot g^{-1}$ (averaged in 25.2 $\mu g \cdot g^{-1}$). The Zn value was in the range of 48.5~224.0 $\mu g \cdot g^{-1}$ (averaged in 107.7 $\mu g \cdot g^{-1}$). The Pb value was in the range of 18.3~217.0$\mu g \cdot g^{-1}$ (averaged in 72.0 $\mu g \cdot g^{-1}$). The Cr value was in the range of 3.7~66.7 $\mu g \cdot g^{-1}$ (averaged in 28.8 $\mu g \cdot g^{-1}$). The Cd value was in the range of 0.15~0.39 $\mu g \cdot g^{-1}$ (averaged in 0.25 $\mu g \cdot g^{-1}$). The Hg value was in the range of 0.013~0.1 $\mu g \cdot g^{-1}$ (averaged in 0.06 $\mu g \cdot g^{-1}$). The As value was in the range of 3.2~7.2 $\mu g \cdot g^{-1}$ (averaged in 5.3 $\mu g \cdot g^{-1}$).

c) Evaluation Results

In the sediments of inner Quanzhou Bay, the OC contents of all the monitoring stations do not exceed the standard. The major transnormal items include sulfide, petroleum, Cu, Zn and Pb. The exceeding standard rates are 22%, 44%, 11%, 11% and 33% respectively. The Hg and As contents do not exceed the standard.

In the sediments of open Quanzhou Bay, the OC contents of all the monitoring stations do not exceed the standard. The major transnormal items include petroleum, Cu, Pb and Zn. The exceeding standard rates are 18%, 25%, 25% and 38% respectively. The Hg and As contents do not exceed the standard.

3.2 Distributions

a) OC

The OC contents in the sediments of all monitoring stations in Quanzhou Bay do not exceed the standard. The contents have no obvious difference between the inner bay and the open bay. The distribution is illustrated as Fig. 2.

b) Sulfide

The sulfide content in the sediments of inner bay is higher than it in open bay. The over-standard stations are mainly located in the near-shore shellfish culture areas and the estuary areas of Luoyang

River. This explains that human activities have great impact on the inner bay's sedimentary environmental quality. The exceeding standard rate is 22%. The exceeding standard stations are N2 and N9 in the inner bay. The distribution is illustrated as Fig. 3.

c) Petroleum

The petroleum contents in the sediments of some monitoring stations in Quanzhou Bay exceed the standard. The exceeding standard rate is 57%. The exceeding standard stations are N2, N3, N8, N9 and W3. A few stations suffered serious pollution are in the channel areas, where petroleum content is higher than the standard. This indicates that the ship activities and the burning of the ship oils in the region are the main source of the sedimentary pollution. The distribution is illustrated as Fig. 4.

d) Cu

The Cu contents in the sediments of some monitoring stations in Quanzhou Bay exceed the standard. The contents are increasing from the inner bay to the open bay. The exceeding standard rate is 36%. The exceeding standard stations are N2, W3, and W5. The over-standard stations are mainly located in the channel areas. This indicates that ship's activities have greater impact on the open bay's sedimentary environmental quality than the activities in coastal areas. The distribution is illustrated as Fig. 5.

e) Zn

The Zn contents in the sediments of some monitoring stations in Quanzhou Bay exceed the standard. The contents are increasing from the inner bay to the open bay.The exceeding standard rate is 49%. The exceeding standard stations are N2, W1, W2, and W3. As same as the circumstance of Cu, the over-standard stations are mainly located in the channel areas where ship's activities have greater impact on the sedimentary environmental quality. The distribution is illustrated as Fig. 6.

f) Cd

The Cd contents in the sediments of all monitoring stations in Quanzhou Bay do not exceed the standard. The contents have no obvious difference between the inner bay and the open bay. The distribution is illustrated as Fig. 7.

g) Pb

The Pb contents in the sediments of some monitoring stations in Quanzhou Bay exceed the standard. The contents are increasing from the inner bay to the open bay.The exceeding standard rate is 53%. The exceeding standard stations are N1, N2, N3, W3, and W5. The distribution is illustrated as Fig. 8.

h) Cr

The Cr contents in the sediments of all monitoring stations in Quanzhou Bay do not exceed the standard. The contents have no obvious difference between the inner bay and the open bay. The distribution is illustrated as Fig. 9.

Hg

The Hg contents in the sediments of all monitoring stations in Quanzhou Bay do not exceed the standard. The contents have no obvious difference between the inner bay and the open bay. The distribution is illustrated as Fig. 10.

As

The As contents in the sediments of all monitoring stations in Quanzhou Bay do not exceed the standard. The contents have no obvious difference between the inner bay and the open bay. The distribution is illustrated as Fig. 11.

3.3 Conclusion

The monitoring results of the sediments in Quanzhou Bay indicate that different monitoring projects present different levels of contamination degrees. There is no pollution caused by Hg and As. The results are basically in according with the sedimentary quality standards of corresponding marine functional areas. The main exceeding standard items are sulfide, petroleum, Cu, Pb and Zn. The areas which are polluted seriously mainly located in the channel areas and anchor stations. It indicats that ship's activities is the main source of the sedimentary pollution.

In additions, the contrast of sediment results between open and inner Quanzhou Bay shows that, the sediment of inner Quanzhou Bay is polluted more seriously than the open Quanzhou Bay. The main reason lies in the inner Quanzhou Bay closed to human. With the common effect of ship's activities, the inner Quanzhou Bay is easily polluted by the pollutants which come from the human activities of coastal areas, while the impact on open Quanzhou Bay is small. What's more, the differences of industrial and agricultural development result in the different pollution levels.

4. Discussions

4.1 Compare the Heavy Metal Contents in Sediments Between Quanzhou Bay and Other Bays

From Table 1, we can see that, the contents of Cu, Zn, Pb, Cr, Cd, Hg and As in the sediments of inner and open Quanzhou Bay are almost equivalent. The contents are lower than the heavy metal contents in sediments of Quanzhou Bay in 2004 [3]. Compared with Tongan Bay, the heavy metal contents are higher in different degrees, especially the Pb content, which is higher than it in Tongan Bay 3~4 times [7]. The Pb content is also higher than it in Shantou Bay 4~5 times, while the contents of Cu, Zn, Cr and Cd in Quanzhou Bay are all lower than those in Shantou Bay [8].

So, we can know that the heavy metal contents in the surface sediments of Quanzhou Bay are decreasing from 2004. This indicates that in recent years, the measurements to control the terrestrial pollutants and the industrial structure adjustments have achieved the desired results.

4.2 *The Control Measurements of Sedimentary Environmental Pollution in Quanzhou Bay*

Sewage and industrial waste water nearby Quanzhou Bay surrounding areas is discharged into the bay mainly through the Jinjiang River, Luoyang River and some ground drain outlet. Heavy metal pollutants have more intense physical, chemical and biological processes in the estuary than the ocean under Hydrodynamic action, a lot of pollutants are absorbed, flocculated and precipitated in the estuary zones [9]. So, it has obvious land-sourced properties. To control the concentration of the heavy metals in the sediments, we must strictly control the terrestrial pollution source and adopt according measures to decrease the total pollutant amounts.

a) Improve the urban living waste treatment system, enhance the performance of sewage treatment plant;

b) Control the business development around Quanzhou Bay strictly, including the leather, gold-plated and dyeing business. Optimize the economic layout and industrial structure;

c) Optimize the distribution of the sewage outfall and implement the eco-dredging project;

d) Promote the concentration of poultry farming and treat the farming sewage in the centralized process.

Table1. The Heavy Metal Contents in Different Bays (10-6)

Study areas	Cu	Zn	Pb	Cr	Cd	Hg	As
Inner part, Quanzhou Bay	22.6	93.4	60.6	11.4	0.2	0.05	4.7

Open part, Quanzhou Bay	26.6	90.1	88.1	7.5	0.2	0.05	5.8
Quanzhou Bay[3]	*29,0*	113	60	53.2	0.3	0.07	9.7
Tong'an Bay[7]	17.0	87.4	23.9	16.0	0.2	0.05	4.8
Shantou Bay[8]	49.6	152.7	15.7	53.45	0.7	/	/

5. Acknowledgment

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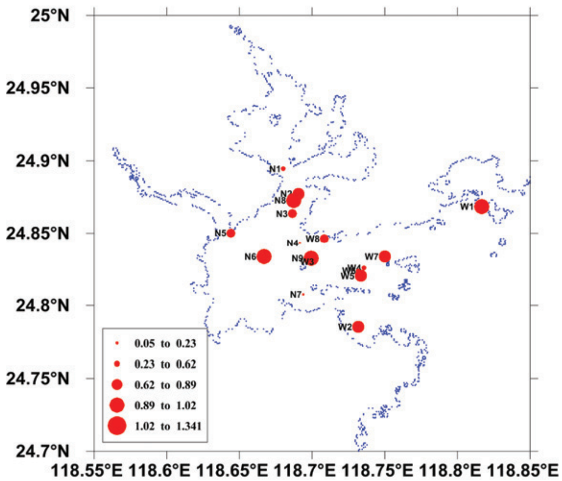

Figure2. The distribution of OC content

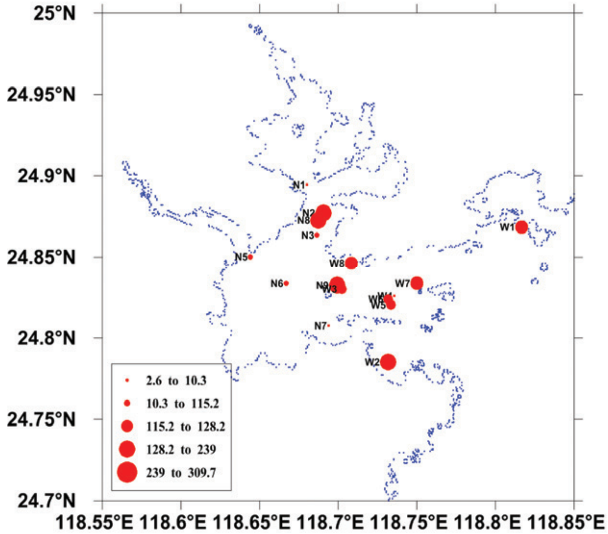

Figure3. The distribution of sulfide content

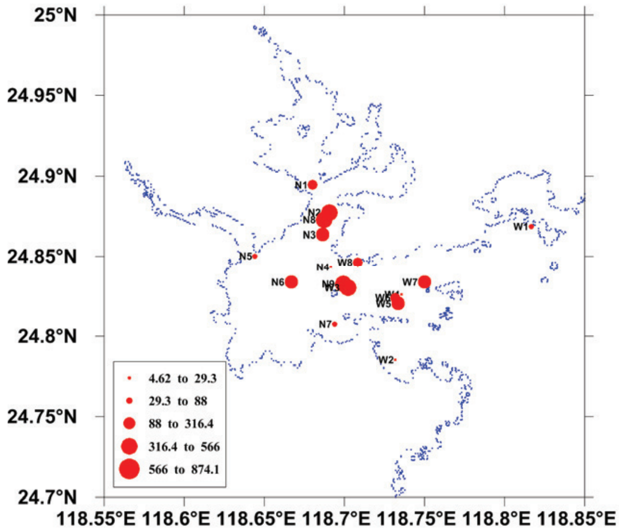

Figure4. The distribution of petroleum content

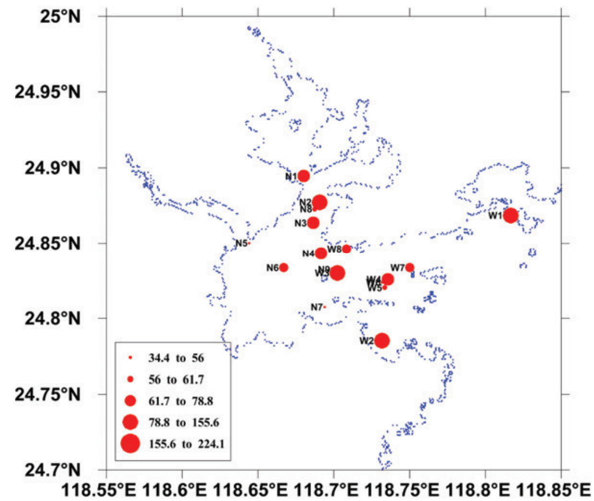

Figure5. The distribution of Cu content

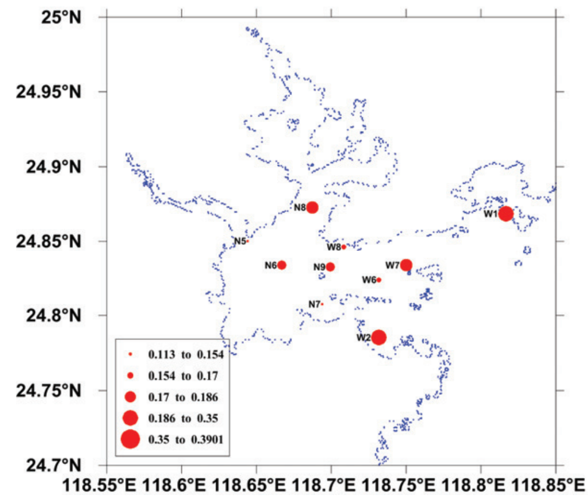

Figure6. The distribution of Zn content

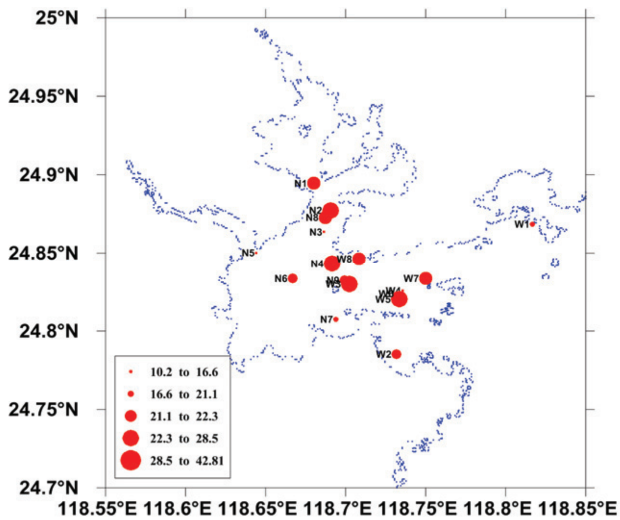

Figure7. The distribution of Cd content

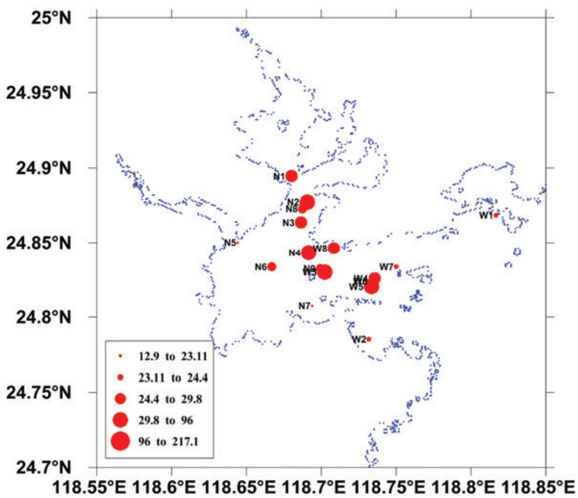

Figure8. The distribution of Pb content

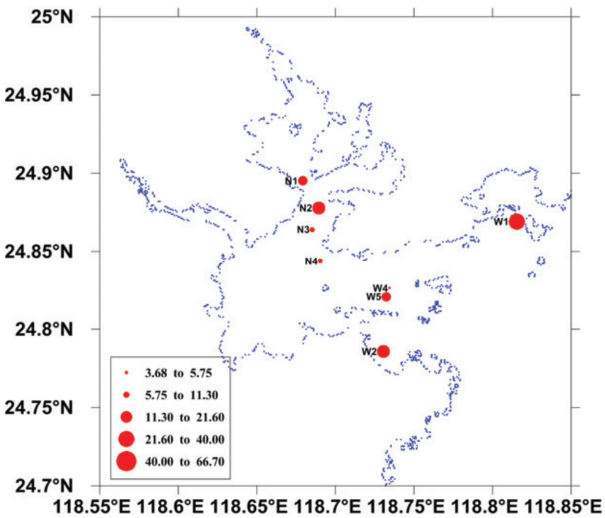

Figure9. The distribution of Cr content

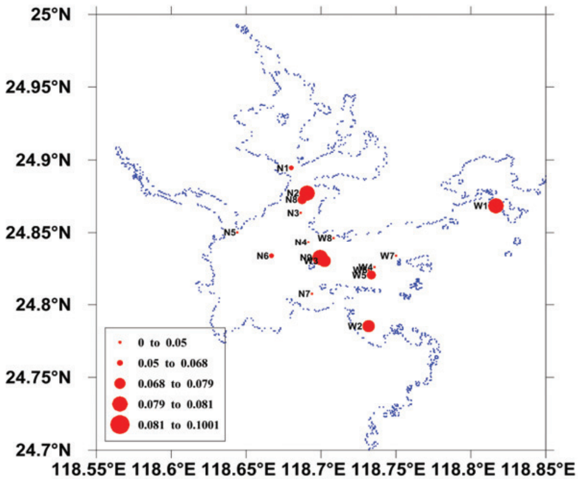

Figure10. The distribution of Hg content

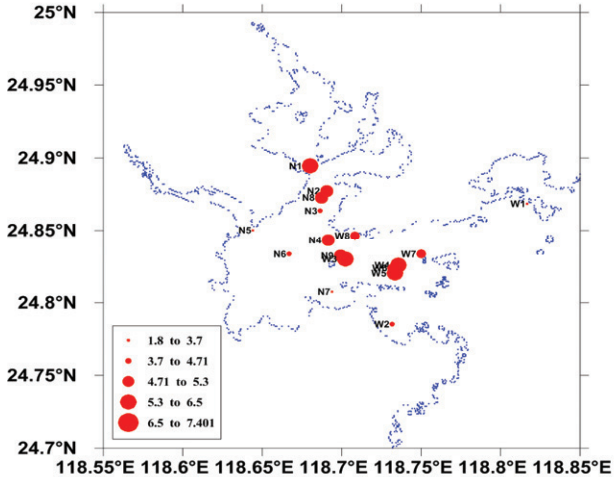

Figure11. The distribution of As content