Study on the Health Status and Change Trend of Ecosystem in the Pearl River Estuary

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Abstract. In order to evaluate the health status of the Marine ecosystem in the Pearl River Estuary, this paper evaluated the health level of the Marine ecosystem from five aspects: seawater environmental health index, sediment environmental health index, biological residue health index, biological health index and habitat environmental health index. The evaluation results showed that from 2012 to 2018, the water environment, sediment environment, biological habitat and biological residual toxicity indexes of Zhuhai Estuary were mainly healthy, while the biological evaluation indexes were generally sub-healthy, resulting in the evaluation results of the Marine ecosystem health index of the Pearl River Estuary were sub-healthy.

Keywords: Pearl River Estuary · biological evaluation index · ecosystem health index · sub-health

1 Introduction

Located in the southern part of Guangdong Province, the Pearl River Estuary is one of the three famous estuaries in China. It is the outlet of the Pearl River into the South China Sea. In recent decades, the process of urbanization and economic development have brought serious pollution to the Pearl River Estuary and its adjacent waters, leading to the deterioration of water quality, seasonal hypoxia of bottom seawater, serious eutrophication of seawater, frequent occurrence of red tides, continuous decline of fishery resources, and a downward trend of biomass and biodiversity [1–3]. Organic pollution and eutrophication have become environmental problems of great concern in the Pearl River Estuary [4].

The Pearl River Estuary is a subtropical area. Under the influence of global climate change and unreasonable development activities, the ecological functions of the coastal waters have been degraded, biodiversity has been reduced, and the problem of seawater eutrophication has been prominent. Current studies have shown that the ecosystems of the Yellow River Estuary, Yangtze River Estuary, Pearl River Estuary, Jinzhou Bay and Laizhou Bay have turned from unhealthy to sub-healthy in recent years [5].

The period from 2012 to 2018 is the period of large-scale construction of Guangzhou Port. In order to study the influence of the construction of Guangzhou Port on the Marine ecosystem of Pearl River Estuary, this paper evaluates the ecosystem health index of Guangzhou Port from 2012 to 2018, and studies the impact of the construction of Guangzhou Port on the Marine ecological environment.

R. Lotfi et al. (Eds.): UPRE 2023, AEBMR 253, pp. 89–97, 2023.
https://doi.org/10.2991/978-94-6463-218-7_11

2 Materials and Methods

2.1 Source of Information

The current status evaluation data are quoted from the current status investigation data conducted by my unit in Guangzhou for many times. The resource sources and monitoring data are shown in Table 1.

Table 1. Data sources and monitoring contents

Season	Time of monitoring	Source of Data	Water quality	Sediment	Ecology of the sea	Animals that swim	Fish eggs and larvae	Mass of organism
Spring	2012.3	Investigation on current environment of Guangzhou Port deep water Channel widening Project			+	+	+	+
	2015.4	Report on Monitoring and investigation of Marine ecological environment and fishery resources in Nansha Phase IV Project of Guangzhou Port		+	+	+		
	2017.4	Investigation report on the Marine environment status of Guishan Anchor (18GSA) Extension Project of Guangzhou Port and New Construction of Dangerous Goods Vessel Anchorage Project of Sanya Discharging South of Guangzhou Port			+	+	+	
	2018.4	Investigation report on Marine environment status of Dahu Island Public Channel Project of Guangzhou Harbor Ring		+	+	+	+	+

(*continued*)

Table 1. (*continued*)

Season	Time of monitoring	Source of Data	Water quality	Sediment	Ecology of the sea	Animals that swim	Fish eggs and larvae	Mass of organism
Autumn	2012.8	Marine Environmental Impact Tracking and Monitoring Report of the third phase of the Guangzhou Port Waterway Project		+	+			
	2015.9	Report on Monitoring and investigation of Marine ecological environment and fishery resources in Nansha Phase IV Project of Guangzhou Port			+	+		+
	2016.11	Investigation report on the Marine environment status of Guishan Anchor (18GSA) Extension Project of Guangzhou Port and New Construction of Dangerous Goods Vessel Anchorage Project of Sanya Discharging South of Guangzhou Port		+	+			+
	2017.9	Investigation report on Marine ecological environment of International General Wharf Project in Nansha Port Area of Guangzhou Port		+				

(*continued*)

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Season	Time of monitoring	Source of Data	Water quality	Sediment	Ecology of the sea	Animals that swim	Fish eggs and larvae	Mass of organism
	2017.11	Investigation report on Marine environment status of Dahu Island Public Channel Project of Guangzhou Harbor Ring			+	+		+

2.2 Method of Evaluation

The selection of Marine ecosystem health assessment indicators follows the principles of integrity, simplicity, operability, representativeness, difference, scientificity and independence. According to the "Assessment Methods for the ecological and environmental Health of Estuarine and Gulf ecosystems" in the Guide for Assessment of Coastal Marine Ecological Health (HY/ T087-2005), five types of assessment indicators are selected: (1) Seawater environmental indicators, including dissolved oxygen concentration, pH value, active phosphate, inorganic nitrogen and petroleum content; (2) Sediment environmental indicators, including organic carbon and sulfide content; (3) Changes of biological habitat indicators, including coastal wetland area and the content of sediment components; (4) Biological residual toxicity index, including mercury, cadmium, lead, arsenic and petroleum hydrocarbon content; (5) Biological indicators, including phytoplankton density, zooplankton density, zooplankton biomass, egg and larval fish density, benthic density and benthic biomass. See Table 2 for the weight of each index, and Table 3 for the criteria of each evaluation index.

3 Evaluation Results and Discussion of Ecological Health Index

Based on the survey data from 2012 to 2018, the evaluation results of various environmental indicators in the coastal waters of the Pearl River Estuary were analyzed and shown in Tables 4, 5, 6, 7, and 8.

3.1 Seawater Environmental Assessment

The seawater environmental health index was determined according to the five top factors of dissolved oxygen, pH value, active phosphate, inorganic nitrogen, and stone class. The results are shown in Table 4. It can be seen that the seawater environmental health index has been improved, and only 2012 was sub-healthy, while all other years were healthy. Results The monitoring results showed that in terms of specific pollution factors, the poor seawater quality environment in 2012 was caused by the serious pollution of active phosphorus phosphate and inorganic nitrogen.

The study of CAI Yangyang et al. also showed that the water eutrophication in Zhuhai Estuary was relatively obvious in 2012, and the main pollution factors were inorganic nitrogen and active phosphate [3], which was also consistent with the results of this

Table 2. Evaluation indexes and weights of estuarine and gulf ecosystem health

Index of evaluation	Water environment	Sedimentary environment	Residual biological poison	Habitat	Biological
Weights	15	10	10	15	50

Table 3. Evaluation index criteria of estuarine and gulf ecosystem health status

Evaluation indicators (health indicators)	Level		
	Health	Sub-health	Not healthy
Water environment (W_{indx})	$11 \leq W_{indx} \leq 15$	$8 \leq W_{indx} < 11$	$5 \leq W_{indx} < 8$
Sedimentary environment (Sindx)	$7 \leq W_{indx} \leq 10$	$3 \leq W_{indx} < 7$	$1 \leq W_{indx} < 3$
Habitat of organisms (Eindx)	$11 \leq W_{indx} \leq 15$	$8 \leq W_{indx} < 11$	$5 \leq W_{indx} < 8$
Residual biological poison (Rindx)	$7 \leq W_{indx} \leq 10$	$4 \leq W_{indx} < 7$	$1 \leq W_{indx} < 4$
Biological (Bindx)	$35 \leq W_{indx} \leq 50$	$20 \leq W_{indx} < 35$	$10 \leq W_{indx} < 20$
Marine ecosystems (Ecological health Index)CEH_{indx}	$CEH_{indx} \geq 75$	$50 \leq CEH_{indx} < 75$	$CEH_{indx} < 50$

study. This is mainly because the Pearl River runoff brings a large number of organic pollutants to degrade and consume DO. In addition, the water exchange conditions in the bay are poor, and the pollutants are not easy to diffuse, which leads to the decrease of the mass concentration of DO.

3.2 Seawater Environmental Assessment

The cycle of sulfide in sediments also plays an important role in environmental pollution. The formation and burial of sulfide are considered to be the main ways of sulfur removal, and sulfide in sediments is an important factor in the assessment of Marine environmental pollution [6]. Sediment is the main form of organic matter occurrence, and the organic carbon stored in global estuarine and continental shelf sediments accounts for about 90% of Marine sedimentary environment [7]. To study the source, distribution and influencing factors of sediment organic matter (SOM) in estuarine is very important for understanding the biogeochemical cycle of SOM.

In this paper, the index values of organic carbon and sulfide are used to evaluate the sediment environmental health index, as shown in Table 5. Specifically, the health levels of the monitored sediments are all healthy. This conclusion is consistent with the research results of Shang Bowen et al. [8].

Table 4. Seawater environmental assessment

Time	Index assignment					Marine Environmental Health Index	Level
	DO	pH	Reactive phosphate	Inorganic nitrogen	Petroleum		
2012	11.01	14.93	5.00	5.00	12.84	9.76	Sub-health
2015	10.88	15.00	9.44	5.13	15.00	11.77	Health
2016	14.75	15.00	11.38	11.13	15.00	13.71	Health
2017	13.38	14.50	10.06	9.44	14.69	12.65	Health
2018	14.00	15.00	9.25	5.13	15.00	12.75	Health

Table 5. Sediment environmental assessment

Time	Index assignment		Sediment Environmental Health Index	Level
	Organic carbon	Sulphide compounds		
2012	10.00	10.000	10.00	Health
2015	7.25	10.00	8.63	Health
2016	10.00	10.00	10.00	Health
2017	10.00	10.00	10.00	Health
2018	10.00	10.00	10.00	Health

3.3 Evaluation of Biological Residual Toxicity

Many studies have shown that heavy metal pollution has posed a great threat to important components of Marine ecosystems, such as biodiversity, the integrity of biological chain and the habitat environment of organisms [9]. Hakanson et al. (1980) proposed the use of potential ecological risk index to evaluate the heavy metal pollution degree, fully considering the toxicity level of heavy metals and the sensitivity of Marine organisms to the heavy metals, and comprehensively reflecting the risk caused by heavy metals to Marine ecosystems [10], which is one of the commonly used Marine surface sediment quality evaluation methods [11].

In this study, the biological residue health index was mainly evaluated based on five heavy metals including arsenic, cadmium, mercury, lead and petroleum hydrocarbons, and the results were shown in Table 6. As can be seen from Table 6, the health index of biological residual toxins was sub-health only in 2012, and healthy in other years. As for the changes of specific heavy metal factors, the main reason for the changes was that cadmium pollution was more serious in 2012. The research results of Chen Bin et al. on the sediments of the Pearl River Estuary also showed that the average potential ecological risk coefficient of heavy metal Cd in surface sediments of the Pearl River Estuary reached the level of medium potential ecological risk [9].

Table 6. Biological residual toxicity evaluation

Time	Index assignment					Biological residue health index	Level
	As	Cd		Pb	Petroleum hydrocarbon		
2012	6.25	3.00	Health	5.00	10.00	6.85	Sub-health
2015	6.67	5.00	Health	5.00	10.00	7.33	Health
2016	8.33	5.00	Health	5.00	10.00	7.67	Health
2017	5.00	5.00	Health	5.00	10.00	7.00	Health
2018	7.50	5.00	Health	5.00	10.00	7.50	Health

Table 7. Biological evaluation

Time	Index assignment						Biological evaluation	Level
	Phytoplankton density	Zooplankton density	Zooplankton biomass	Egg and larva density	Density of benthic organisms	Benthic biomass		
2012	29.17	10.00	12.50	43.33	19.17	17.50	21.94	Sub-health
2015	24.17	10.00	17.50	20.00	19.17	13.33	17.36	Not healthy
2016	11.67	10.00	30.00	40.00	21.67	15.00	21.39	Sub-health
2017	21.67	10.00	17.22	37.78	22.50	15.00	20.69	Sub-health
2018	16.67	10.00	11.67	43.33	18.33	18.33	19.72	Not healthy

3.4 Biohealth Index Evaluation

The biological health index was mainly evaluated according to six indicators, namely phytoplankton density, zooplankton density, zooplankton biomass, fish egg and larval density, benthic density, and benthic biomass, and the results were shown in Table 7. As can be seen from Table 7, the level of biohealth index is poor, mainly unhealthy and sub-healthy.

3.5 Habitat Environmental Assessment

In this paper, the habitat environmental health index was determined according to the decrease of coastal wetland habitat and the annual change of sediment major components in 5 years. In general, the habitat environmental health index in the Pearl River estuary was rated as healthy.

3.6 Marine Ecosystem Assessment

The Marine ecosystem evaluation results of the coastal waters of the Pearl River Estuary are shown in Table 9. In recent years, the ecosystem of the Pearl River Estuary has been at the sub-health level. The lowest value of the Marine ecosystem health index appeared

Table 8. Habitat environmental assessment

Time	Index assignment		Habitat environmental health Index	Level
	Coastal wetland habitat decreased in 5 years	Annual variation of major components in sediments		
2012	15	15	15	Health
2015	15	15	15	Health
2016	15	15	15	Health
2017	15	15	15	Health
2018	15	15	15	Health

Table 9. Marine ecosystem assessment

Time	Marine Environmental Health Index	Sediment Environmental Health Index	Biological residue health index	Biological Habitat Health Index	Biological health index	Marine Ecosystem Health Index	Level
2012	9.76	10.00	6.85	15.00	21.94	63.55	Sub-health
2015	11.09	8.63	7.33	15.00	17.36	59.41	Sub-health
2016	13.45	10.00	7.67	15.00	21.39	67.51	Sub-health
2017	12.41	10.00	7.00	15.00	20.69	65.10	Sub-health
2018	11.68	10.00	7.50	15.00	19.72	63.90	Sub-health

in 2015 and the highest value appeared in 2016. The main reason for the low health index in 2015 was that most stations did not collect fish eggs and larvae, which resulted in the low biological health index.

4 Conclusion

Combined with the construction of Guangzhou Port, this paper evaluated the trend and health status of Marine biochemical changes in the Pearl River from 2012 to 2018. The results showed that:

1. In recent years, the ecosystem of the Pearl River Estuary has been in the sub-health level, and the structure of the ecosystem is relatively stable. The main reason for the sub-health of the ecosystem of the Pearl River Estuary is that the biological evaluation index is sub-health or unhealthy.
2. The sediment environment and habitat environment of the Pearl River Estuary are generally good, and both belong to the healthy level.
3. The biological residue health index is generally a healthy level, and it is mainly seriously polluted by Cd when it is sub-healthy.

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