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Retrospective Environment Carrying Capacity Assessment and Comparison for Marine Reclamation

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Abstract

For improving the managed level and guiding the environmental management of reclamation engineering, a synthetic assessment method based on cloud theory is applied to evaluate the environment carrying capacity of part of Tianjin Port in this paper. This retrospective assessment of carrying capacity aims to obtain the historical development situation of reclamation domain. The research is meaningful and efficient for judging the feasibility of marine reclamation.

Keywords

Retrospective; Environment Carrying Capacity; Assessment; Reclamation; Cloud Theory

1. Introduction

Recently, marine reclamation has resulted in the pollution of water environment and the destruction of ecological system. The environmental and ecological problem is the important restricting factor for regional sustainable development. How to evaluate the environmental impact of marine reclamation is very important for managing and guiding the district development scientifically.

Tianjin Port is an important port in our country. The rapid development of Tianjin Port results in more demand of marine resources, especially the land resource. So a new reclamation planning has been studied and presented to solve the problem of development space, namely Ergangdao Island. But the Tianjin Port locates in the west of Bohai Bay, the environmental impact is the key problem for deciding the feasibility of Ergangdao Island reclamation. So the historical environment situation of this district must be studied to obtain the basic condition of reclamation.

A basic assessment problem exists in this research. The characteristic of assessment is a combined process between assessment factors and assessment standard. So many assessment methods have been proposed and applied to many fields including ocean water quality and carrying capacity, such as Individual and comprehensive index method, fuzzy comprehensive evaluation method (Qian, 2006), grey clustering method (Feng, Wang, &

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Zhang, 2000), matter element model analysis method (Pan, Fu, & Liang, 2002), projection pursuit method (Wang, 2011), artificial neural network method (Chen & Li, 2005) and nonlinear set pair analysis method (Li, Zhang, & You, 2010), but several defects exist in these methods (Li & Liu, 2009).

In this paper, a synthetic assessment method, namely cloud theory (Li & Du, 2005) is applied to evaluate the historical situation in Tianjin district, based on the characteristic of randomness and ambiguity. The research results show the situation of reclamation district and the efficiency of this method.

2. Assessment Method

2.1. Cloud Theory

Based on probability and fuzzy mathematic, the basic algorithm of cloud theory is to build an uncertainty transformation model for the exchange between concept and quantity. The cloud theory model has been applied to system evaluation, algorithm improvement, decision support, intelligent control, data mining, knowledge discovery and network security (Fu, Li, & Wang, 2011).

2.2. Procedure of Cloud Theory Assessment Method

The randomness and ambiguity of concept can reacted in cloud theory by the mathematical expectation, entropy and hyper entropy. The detailed assessment procedure has seven steps (Li, Zhang, Si, Liang, & Sun, 2012).

3. Case Study

Tianjin Port is an important support for district economy development. A new reclamation planning named that Ergangdao Island is proposed to improve the land resource for the rapid development of Tianjin Port and the demand of marine resources. In this research, the historical environment situation of this district is studied for obtaining the basic condition of reclamation and judging the feasibility of Ergangdao Island reclamation. Marine reclamation of Ergangdao Island is shown in **Figure 1**.

The grey section in **Figure 1** is the panning reclamation of Ergangdao Island.

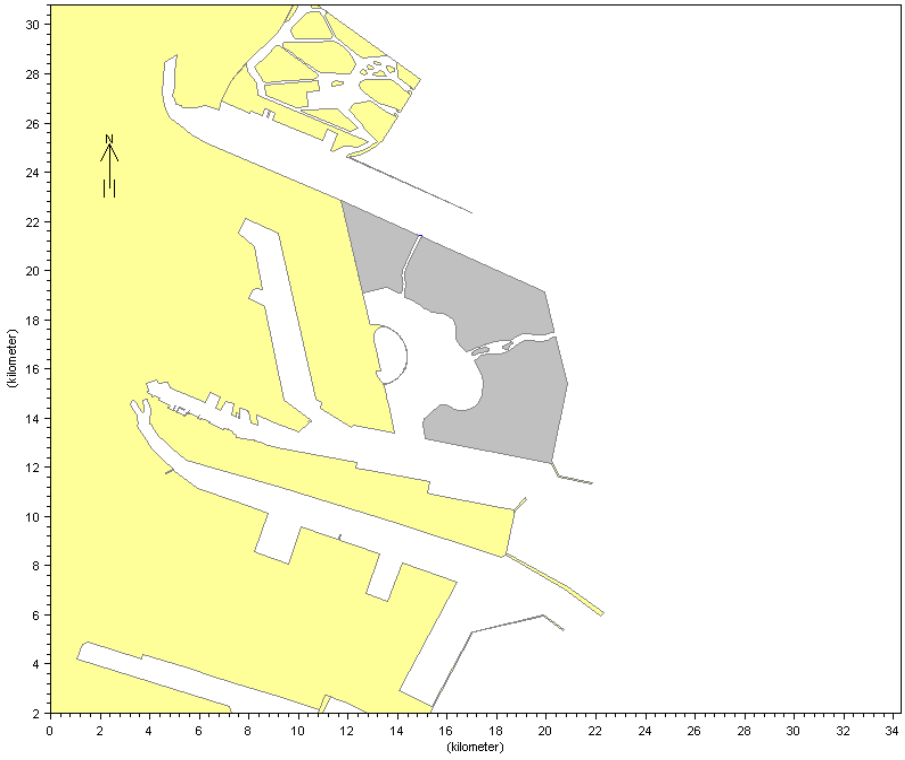

Figure 1. The location of Ergangdao Island.

3.1. Basic Situation of Reclamation Domain

The total area of Tianjin marine is about 15,900 km^2. It is very shallow and its averaged water depth is less than 20 m. The sea bottom is very flat and its mean slope is less than 2‰.

3.2. Assessment Indexes of Environment Carrying Capacity

Thirteen assessment indexes (Suspended Substance (SS), COD, DO, DIN, Phosphate (Ph), Petroleum (Pe), Hg, As, Cu, Zn, Cd, Pb and Cr) in marine waters, ten assessment indexes (Organic Carbon (OC), Sulfide (Su), Petroleum (Pe), Hg, As, Cu, Zn, Cd, Pb and Cr) in sediment and five assessment indexes (Chl, Phytoplankton (Pp), Zooplankton (Zp), Benthos (Be) and Intertidal benthos (Ib)) are selected for evaluating the current situation of engineering marine district. In this paper, single factor carrying capacity and multiple factors comprehensive carrying capacity are studied for evaluating the historical situation of reclamation domain from multiple angles.

3.3. Assessment Levels of Environment Carrying Capacity

The assessment standard of the whole indexes is used to evaluate retrospective environment carrying capacity listed in **Table 1**.

Table 1. Level standards of assessment index.

Assessment indexes	Level standards			
	Good (I)	General (II)	Poor (III)	Very poor (IV)
SS	0-10	10-100	100-150	150-Max[1]
COD	0-2	2-3	3-4	4-Max[2]
DO	Max[3]-6	6-5	5-4	4-3
DIN	0-0.2	0.2-0.3	0.3-0.4	0.4-Max[4]
Ph	0-0.015	0.015~0.03	0.03~0.045	0.045-Max[5]
Pe	0-0.05	0.05~0.3	0.3~0.5	0.5-Max[6]
Hg	0-0.05	0.05~0.2	0.2~0.5	0.5-Max[7]
As	0-20	20-30	30-50	50-Max[8]
Cu	0-5	5-10	10-50	50-Max[9]
Zn	0-20	20-50	50-100	100-Max[10]
Cd	0-1	1~5	5~10	10-Max[11]
Pb	0-1	1~5	5~10	10-Max[12]
Cr	0-50	50-100	100-200	200-Max[13]
OC	0-2	2-3	3-4	4-Max[14]
SU	0-300	300-500	500-600	600-Max[15]
Pe	0-500	500-1000	1000-1500	1500-Max[16]
Hg	0-0.2	0.2-0.5	0.5-1.0	1.0-Max[17]
As	0-20	20-65	65-93	93-Max[18]
Cu	0-35	35-100	100-200	200-Max[19]
Zn	0-150	150-350	350-600	600-Max[20]
Cd	0-0.5	0.5-1.5	1.5-5	5-Max[21]
Pb	0-60	60-130	130-250	250-Max[22]
Cr	0-80	80-150	150-270	270-Max[23]
Chl	0-2	2-5	5-10	10-Max[24]
Pp	0-25	25-50	50-150	150-Max[25]
Zp	Max[26]-3	3-2	2-1	1-0
Be	Max[27]-3	3-2	2-1	1-0
Ib	Max[28]-3	3-2	2-1	1-0

Note: Max[1]-Max[28] is the max value of water quality measurement data owing to not be obtained by the water quality standard.

3.4. Results Analysis

Following the assessment steps of cloud theory, the single factor and multiple factors method are applied to evaluate the water quality, sediment, ecology and comprehensive level in **Table 2-8**.

From the assessment results in **Table 2-3**, the water quality is good in 2010 and 2012. But the Phosphate is poor in the research years.

The sediment quality is good in 2010 and 2012 shown in the **Table 4** and **Table 5**. Especially 2010, all the indexes are the level I.

The level of ecology indexes is poor (III) in 2010 and 2012.

The comprehensive assessment results show the level is acceptable.

4. Conclusion

In this paper, a synthetic assessment method based on cloud theory is applied to evaluate the marine reclamation

Table 2. Assessment results of water quality in 2010.

Assessment indexes	Assessment level	
	Single factor	Multiple factors
SS	II	
COD	II	
DO	I	
DIN	III	
Ph	II	
Pe	I	
Hg	II	I
As	I	
Cu	I	
Zn	I	
Cd	I	
Pb	II	
Cr	I	

Table 3. Assessment results of water quality in 2012.

Assessment indexes	Assessment level	
	Single factor	Multiple factors
SS	I	
COD	II	
DO	I	
DIN	III	
Ph	I	
Pe	I	
Hg	II	I
As	I	
Cu	I	
Zn	I	
Cd	I	
Pb	II	
Cr	I	

Table 4. Assessment results of sediment in 2010.

Assessment indexes	Assessment level	
	Single factor	Multiple factors
OC	I	I
SU	I	
Pe	I	
Hg	I	
As	I	
Cu	I	
Zn	I	
Cd	I	
Pb	I	
Cr	I	

Table 5. Assessment results of sediment in 2012.

Assessment indexes	Assessment level	
	Single factor	Multiple factors
OC	I	I
SU	I	
Pe	I	
Hg	I	
As	II	
Cu	I	
Zn	I	
Cd	I	
Pb	I	
Cr	I	

Table 6. Assessment results of ecology in 2010.

Assessment indexes	Assessment level	
	Single factor	Multiple factors
Chl	II	III
Pp	I	
Zp	III	
Be	III	
Ib	III	

Table 7. Assessment results of ecology in 2012.

Assessment indexes	Assessment level	
	Single factor	Multiple factors
Chl	II	III
Pp	III	
Zp	III	
Be	IV	
Ib	III	

Table 8. Comprehensive assessment results.

Year	Assessment level
2010	I
2012	II

carrying capacity of Ergangdao Island in Tianjin Port. Through the retrospective assessment, the historical development situation in reclamation domain is shown by single factor and multiple factors assessment. The assessment results show that the environmental level is acceptable for marine reclamation. Meanwhile, more researches need be done for obtaining the environmental impact level of marine reclamation, such as hydrodynamics, water exchange, ecological loss and sediment etc.

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