



Study on Damage of Tourism Function Based on Lake Pollution - A Case of Chaohu Lake, China

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ABSTRACT

Lakes are important tourist destination around the world. A quarter of the lakes is a national scenic in China. The paper analysed tourism function damage of Chaohu lake in China, which is based on comparing the standard of water tourism project. The results show that Chaohu lake has unique natural conditions, such as water depth, temperature, flow, etc. Suitable natural conditions are conducive to water entertainment. Water pollution caused physical and chemical properties changes, such as transparency, pH and floating materials, etc., which limited the tourism development of Chaohu lake, especially close to water project. The paper referred to the literature, calculated water pollution degree and tourism function damage of Chaohu lake. The results show that the water pollution makes swimming loss, water entertainment serious damage, and leisure vacation middle damage. Pollution is mainly eutrophication. Tourism losses have not reached maximum. Chaohu lake should take eco-environment restoration and protection as the prerequisite considering function regionalization and control pollution level.

INTRODUCTION

Chaohu lake belongs to the three rivers and three lakes of major water pollution prevention valleys in China. Water quality of Chaohu lake is directly related to the local social and economic development (Wang et al. 2007). There are many researches about Chaohu lake environment, which include pollution causes (Liu et al. 2012), control measures (Shang & Shang 2007), environmental evaluation (Zhao 2009, Xie et al. 2010), etc. But it is rare to study the tourism environmental conditionality of Chaohu lake. Water pollution of Chaohu lake is serious and tourism functions have been damaged. The paper apply evaluation theory about water pollution damage (Hao et al. 2010, Chen 2000, Chen et al. 2005, Wang & Wang 2012), which compares standards of water entertainment in China, to evaluate tourism advantages and disadvantages of Chaohu lake to analyse Chaohu lake tourism damage.

Important tourist resources: Scenic spot refers to the area which has the ornamental, cultural or scientific value, natural landscape, cultural landscape more concentrated, a beautiful environment for people to visit or scientific and cultural activities. China is the one of the richest countries which has scenic resources. From 1982 to 2012, China announced a total of eight batches of the national scenic, a total of 225. Among 70% of the water scenic have been concentrated and published before 2002, which shows that water tourist resources are classic, main and a strong tourist attraction.

Table 1 shows that the number is total 128 of single and comprehensive water national scenic in China. Among the national scenic, rivers and lakes account for half of all.

Table 2 shows that there are three provinces for which the maximum ratio of the water national scenic accounted for 100%, such as Hainan, Qinghai and Xizang. The second is Xinjiang province with proportion of 80%. Besides that, the absolute number of the water national scenic in Guizhou and Yunnan provinces is ahead in China. Their relative proportions are also bigger. The water national scenic is an important tourism resource, especially lakes. The generic types of lakes have many reasons, their forms are also different. The scene is picturesque and very peaceful. These features make lakes to become the best holiday resort.

Serious pollution of lakes: The pollution phenomenon of water environment is more serious. Lakes are closely linked with human life. According to the 2011 state of the environment bulletin in China, 26 of the nine-monitored lakes have been found to be Class I-III, Class IV-V and poor Class V, which have proportion of 42.3%, 50.0% and 7.7%, respectively. The main pollution indicators are TP and COD. Lakes are in medium nutrition, mild nutrition and eutrophication. Their proportion is 46.2%, 46.1% and 7.7%, respectively. Lake's eutrophication problem is still outstanding.

Pollution restricts tourism development: Polluted water can cause the deterioration of the water environment. Some pollutants can make the water stench, peculiar smell, colour change and foam and oil film, which brings the pollution of

Table 1: Type and proportion of the water national scenic, China.

Type	Rivers	Lakes	Seas	Fall, sand, spring	Mountains and rivers	Total
Number	34	31	9	5	49	128
Proportion (%)	26.6	24.3	7.0	3.9	38.2	100

Source: http://www.mohurd.gov.cn/jsbflld/201212/t20121204_212185.html.

Table 2: Proportion of the national scenic of the water type, China.

Province	Hainan	Qinghai	Xizang	Xinjiang	Guizhou	Hubei	Yunnan	Zhejiang
Number	1	1	4	4	14	5	8	8
Proportion (%)	100	100	100	80	77.8	71.4	66.7	42.1

Source: http://www.mohurd.gov.cn/jsbflld/201212/t20121204_212185.html.

vision, smell and taste to tourists, and gives adverse effects on visitor's health. Many tourist activities can not be carried out because water does not comply with the environmental requirements, such as beach, fishing, watching, swimming, diving, etc. The revisit rate becomes low and tourism loss will increase.

Chaohu lake as an important tourist destination:

Resources protection is key to a scenic area development. With Chaohu lake being surrounded by the city, and a lager city around lake being constructed in Hefei in Anhui province, tourism is inevitably closely linked with Chaohu lake environment quality. Tourism is one of the functions of Hefei city. Therefore, the paper chooses Chaohu lake as the research, which has an important theoretical and practical significance.

THE STUDY AREA

Chaohu lake is located between the 117°16'54" E-117°51'46" E and 30°25'28" N-31°43'28" N. Chaohu lake belongs to the left water system of the Yangtze river downstream, and is one of the five largest freshwater lakes in China. Administrative division was adjusted in Anhui province in 2011. Chaohu lake is surrounded by Hefei, capital of Anhui province. Around the Chaohu lake county have Baohe district, Feidong County, Chaohu County, Lujiang County, Feixi County, etc. Chao lake is divided into east and west half lake, bounded by the Zhongmiao-Laoshan. There is some difference in the water environment between the east lake and the west lake.

There are both modern metropolises and vast rural sceneries around the Chaohu lake. There are not only outstanding people but the most abundant tourism resources intra-regional, especially the water tourism resources. River, lake, hot spring, pond are called "four wonders". Chaohu lake is the core of the waterscape. Chaohu lake water has been pol-

luted for a long time. According to the 2011 state of the environment bulletin in China, the main pollutants which enter from the rivers into Chaohu lake are TN and TP, petroleum and ammonia nitrogen, etc. In recent years, water environment problem of Chaohu lake is more outstanding. According to the division standard of lake eutrophication, all lake regions are in eutrophication. It will be discussed how to scientifically use lakes resources. This article evaluates environment conditionality of Chaohu lake tourism development from the two aspects of qualitative and quantitative, in accordance with the water environmental requirement of relevant water entertainment.

MATERIALS AND METHODS

Methods were fuzzy evaluation and quantitative analysis.

Fuzzy evaluation: Fuzzy evaluation was to compare the physico-chemical properties of Chaohu lake and the water entertainment standards in China, to find tourism advantages and disadvantages of Chaohu lake. Standards for physico-chemical properties are such as depth, temperature, flow, transparency, pH, floating material and wind speed etc., and water entertainments are such as swimming, yachting, diving, underwater landscape, surfing, water-skiing, fishing and holiday etc. were taken into consideration (Table 3).

Quantitative analysis: Quantitative analysis was to calculate the pollution loss. The economical loss by the water pollution is related to the water pollutant concentration (Fig. 1) (James et al. 1984). Many scholars studied the environmental assessment (Zhang et al. 1999, Deng & Ni 2001, Smith et al. 1999, Ma et al. 2009). The paper collected bulletin data and literature information for fuzzy evaluation and quantitative analysis. Table 4 shows situation of Chaohu lake average water quality in 2010.

The evaluation of water pollution damage mainly discusses three aspects about swimming, water entertainment,

and vacation. Damage evaluation formula of the single function is eq. 1 (Bu & Chai 2001).

$$R_{ij} = \frac{1}{1 + a_{ij} * \exp(-b_{ij} * c_j)} \quad \dots(1)$$

Where “*i*” represents lake certain function, “*j*” represents certain pollutant, R_{ij} represents pollution loss of “*i*” due to “*j*”, C_j represents concentration of “*j*” kind of pollutants, and a_{ij} and b_{ij} are parameters (Table 5).

RESULTS AND DISCUSSION

Not all waters can become tourism environment and tourism resources. Tourism activities belong to high consumption, make people to the pursuit of physical and mental pleasure, therefore, water tourism activities require higher standard of water environment.

Development of water entertainments relying on the lake scenic spot requires surface water Class III and Class IV. According to the surface water environment function and protection target, surface water is divided into five categories in China (Surface Water Quality Standards-GB3838-2002). Class III standard is mainly suitable for secondary reserve of surface water source centralized drinking water, for the fisheries area of wintering grounds, migration channels of fishes and shrimps, for the aquaculture areas and swimming areas. Class IV is only suitable for industrial use and other amusements that do not involve the liquid coming into contact with skin. Index of the water classification standard includes 24 items, such as water temperature, pH, DO (dissolved oxygen), COD, BOD₅, NH₃-N, TN, TP, faecal coliform, etc.

Water entertainments include water competitive projects, ship competitive projects, water-skiing, diving, etc. Water competitive projects include swimming, diving, water polo and synchronized swimming. Ship competitive projects include boating, rowing, wind surfing, and motorboat movement. Water-skiing projects include water skiing, water skiing board and surfing, etc. Lake’s water tourism functions have leisure, vacation, sports health and other. Lake tourism projects include ornamental, swimming, rowing, sailing, water skiing, diving, surfing, fishing, etc., which is priority to the tourist entertainment type. Different water entertainment projects require different water environments as given in Table 3.

Conditions of tourism activities: It is the water environmental conditions that tourism activities need such as landscape, rich and colourful underwater biological life, less suspended matter and plankton, and high transparency. Water environment conform to the standard conducive to tourism activities. Diving activities require calm water, no intense

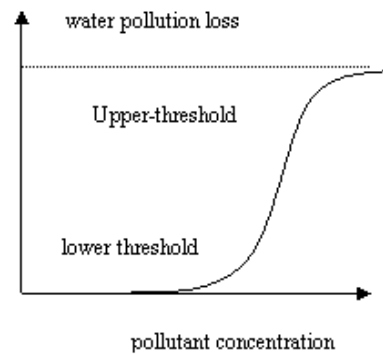


Fig.1: Curve of pollution loss-concentration.

undercurrent and no fierce fish.

Tourism activities of the lake beach should comply with the Surface Water Quality Standards-GB3838-2002, Natatorium Standard, Hygienic Standards for the Design of Industrial Enterprises TJ36 in China, etc.

Conditions of swimming: Natural natatorium conditions include two aspects. First, not be deep and temperature comfortable. According to tourist activities and experiences, depth is advisable with 0.5-1.2 meters. Water temperature should not be less than 22°C, which meets the most groups of normalization demand. Second, water shall be of clean sanitation with no pollution. Water transparency is not less than 0.8m according to the requirements of natural natatorium. In addition, indicators are also specified including pH, pollutants and toxic substances.

Conditions of water sports: Environmental conditions of water sports (surfing, water skiing, sailing, etc.) include two aspects. First, weather conditions require special requirements. Sailing needs certain range of wind speed. Surfing needs certain range of wave height. Second, water shall be clean sanitation with no pollution. These sports in water have a certain contact with body. Therefore, water quality requirements are also higher.

Conditions for others: Some activities have no clear requirements, such as fishing, holiday, yachting, etc. If pollution is too high, it will affect fishing, sightseeing visual senses and mood. Ships (boats) or other water transport facilities have been corroded. Useful life of facilities is affected. In addition, polluted water usually contains toxic substances. Fish may be affected by pollution of water.

Lake water environment quality influences resort quality. According to the Tourist Resort Hierarchy Standard in China, Hierarchies of tourist holiday resort are divided according to the basic and general conditions. The basic is the threshold and necessary condition. Resort area should achieve standard of surface water quality Class III (GB3838 in

Table 3: Comparison of physical and chemical properties of Chaohu lake and water entertainments standards, China.

Physical & chemical properties	Depth	Temperature	Flow	Transparency	pH	Floating material	Wind speed	
Chaohu lake	3m	17.3°C	0.02-0.10m/s	0.16m	7.91	40-1000mg/L	4.1 m/s	
Water entertainment standards	Natural swimming	0.5-1.2m	22°C	≤0.5m/s	≥0.8m	6.0-9.0**	No oil film, no floater	-
	Yacht	-	-	-	-	No strong corrosion	-	-
	Diving, underwater landscape	-	appropriate	Calm waterd ≤0.5m/s	High transparency	-	-	-
	Sailing	≤ 30m	appropriate	Calm water	-	6.0-9.0**	No oil film, no floater	3-20 m/s
	Surfing Water-skiing	-	-	Wave height 0.3m-1.0m*	-	-	-	-
	Fishing, Holiday	Surface water quality should achieve Class III (GB 3838,China)						

*Surfing, **According to TJ36 Tab.3 or GB3079 (in China)

Table 4: Situation of Chaohu lake average water quality in 2010 (mg/L).

BOD5	TN	TP	Volatile phenol	As	Hg	Cd	Pb
3.044	1.874	0.183	0	0.0009	0.0003	0.0012	0.002

Table 5: "a, b" parameters numerical about the pollution loss rate of lake function.

Function	Parameters	BOD5	TN	TP	Volatile phenol	As	Hg	Cd	Pb
Swimming	<i>a</i>	5083.7	321.6	321.6	160.6	160.6	119.4	108.6	160.6
	<i>b</i>	1.31	4.71	47.13	96.74	9.67	18.76	18.56	9.67
Water entertainment	<i>a</i>	18895.6	799.4	799.4					
	<i>b</i>	1.31	4.18	41.77					
Vacation	<i>a</i>	3909.7	368.0	368.0					
	<i>b</i>	0.92	2.63	26.26					

China).

Integrated above fuzzy evaluation, it is key factor that the poor water quality restricts water sports of Chaohu lake. Do not consider water quality impact, appropriate conditions of water temperature, flow, water depth will be very suitable for developing water entertainment, such as fishing, holiday, water games, etc.

Evaluation of tourism damage: Lake water function mainly includes fishery breeding, drinking water, swimming, no-direct-contact travelling to human body, living environment (nearby residents and tourists on holiday), agricultural irrigation, etc.

According to eq. 1, the data have been calculated as given in Tables 4 and 5. Pollution loss rate is given in Table 7. On comparing Table 7 with Table 6, it becomes evident that the tourism function of Chaohu lake is much damaged. Swimming comprehensive loss rate is 98.64%. Pollution degree

is very serious. The phenomenon is rare in lakes. Water entertainment has serious damage, comprehensive loss rate is 72.59%. Vacation loss rate is 25.35%, middle pollution and middle damage. There is comprehensive damage to the lake also. Quantitative analysis and fuzzy evaluation results are consistent.

Analysis of single loss rate indicates that the largest is the TN followed by TP. The loss rate of heavy metals pollution is not more than 1%, which belongs to no-damage range. Therefore, the main problem about Chaohu lake is TN and TP. This phenomenon is the same with other lakes and the main problems are of eutrophication.

As the social and economic conditions differ greatly around the Chaohu lake, pollution is not the same. Eastern Chaohu lake is used for drinking water. Water function implements national standard Class II. Western Chaohu lake has serious pollution, and classified as Class V or poor Class

Table 6: Lakes damage degree and Water quality classification standard.

Comprehensive loss rate (%)	Pollution degree	Damage degree	Comprehensive loss rate(%)	Pollution degree	Damage degree
≤ 1	Fine	No-damage	≤ 50	Middle	Middle
≤ 5	A little clean	Micro-damage	≤ 90	Serious	Serious
≤ 20	Light pollution	Mild damage	> 90	Very serious	Loss function

Table 7: Evaluation damage of Chaohu lake water pollution.

Function	Pollution loss rate of single index						
	BOD5	TN	TP	As	Hg	Cd	Pb
Swimming water	0.0104	0.9549	0.9453	0.0062	0.0089	0.0093	0.0063
Entertainment	0.0028	0.7594	0.7231				
Vacation	0.0042	0.7594	0.2493				
Function	Comprehensive loss rate*		Pollutional degree		Damage degree		
Swimming water	0.9864		Very serious		Loss function		
Entertainment	0.7259		Serious		Serious damage		
Vacation	0.2535		Middle		Middle damage		
Comprehensive evaluation	0.6553		Serious		Serious damage		

* TN and TP two indexes cause eutrophication. They are not independent of pollutants. Calculating the comprehensive loss rate, index only choose numerical smaller TP

V for a long time. Take the example of chlorophyll *a*, its concentration is higher in western Chaohu lake with the maximum of 79.53 mg/m³ (Fang et al. 2010).

CONCLUSIONS

Water environment is not suitable for water entertainment activities in Chaohu lake, but water quality is improved (at least Class III). Water environment is very favourable to carry out water tourism because of its appropriate depth, water temperature and flow. Due to pollution, swimming and water entertainment functions have heavy damage. The main problem is that of TN; TP index is too higher. Eutrophication of water will reduce transparency. Lake holidays function also can not reach the ideal state. There is a big difference in quality between east and west half lake. Therefore, developing tourism should consider function regionalization, which is to realize optimum combination of both the protection and economics.

Chaohu lake scenic should take eco-environment restoration and protection as the prerequisite. Water tourist activities should comply with the water environment function division. The study did not obtain detailed data about the Chaohu lake water quality, such as, core area, lake side area, estuary area, around the island area, etc. It is waited for further research how to carry on the Chaohu lake water tourism function partition and combination.

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