Water Quality Trend Assessment of Watershed Corresponding to Socio-Economical Development

Kai Huang[1], Yajuan Yu[2], Shuxia Yu[3], Longhao Ye[2,4], Huaicheng Guo[4]

1. College of Environmental Science and Engineering, Beijing Forestry University, Beijing, China
2. Beijing Key Laboratory of Environmental Science and Engineering, School of Chemical Engineering and Environment, Beijing Institute of Technology, Beijing, China
3. College of Resource and Environment, Huazhong Agricultural University, Wuhan, China
4. College of Environmental Science and Engineering, Peking University, Beijing, China
Email: huangkmail@gmail.com

Abstract: A kind of Relative Water Quality (RWQ) index was introduced to indicate the relationships between water quality and socio-economical development. The RWQ index shows the water resource and aquatic environmental condition of some certain watershed with the population growth and industrial development. Taken Lake Dianchi Watershed as an example, the RWQ indices for both its contributing rivers and the lake were analyzed through this idea. The results showed that the RWQ for Lake Dianchi Watershed was getting better in both its contributing rivers and the lake. This means the water resource and aquatic environment of the watershed remain steady while supporting more and more pressures from population and industries.

Keywords: Relative Water Quality; Lake Dianchi Watershed; Socio-economical indicator

1 Introduction

For those lakes that lie near or around some big cities, the urbanization process always press pollution load to their water quality. Urbanization is an irreversible process [1], accompanying with the urban overspreading. When assessing the water quality of the lakes, the urbanization process [2] should not be omitted. Oversimplifying conclusion for the water quality without taking into account the socio-economical condition [3] of the lake is unreasonable [4]. Especially when the lake slips into the state of eutrophication, the water quality grade comparing with the original water quality standard will remain in a worst grade. However, the worst grade could not indicate the [5].

Lake Dianchi watershed in Yunnan Province, China, is the largest freshwater lake in Southwest China. During the past decades of years, with the rapid development of economy and society around the watershed, the area faces more and more pressure from water pollution. It's necessary [6] to give a comprehensive assessment on the concurrent processes of water body deteriorating socio-economical development.

2 Concurrent of water quality deteriorating and socio-economical development

The Lake Dianchi Watershed is taken as a case study. As the population of the watershed has changed a lot from the 1950' to the 21st century, the relative pollution load also changed during these years. Although the population growth rate is decreasing, the gross population was almost triplicate from 1950 to 2000 [7]. With population growth, the economical level has increased greatly at the same time (Table 1).

Table 1. The Socio-economic Growth of Lake Dianchi Watershed and Kunming City

year	1950	1960	1970	1980	1990	2000
POP	79.70	104.57	120.71	156.80	185.69	217.69
GR	-	31.2	15.4	29.9	18.4	17.2
GDP	-	3.89*	7.50	19.11	115.26	636.13
WQG	I	I	II	III	IV	>V

POP: Population of Lake Dianchi Watershed (10^4 persons); GR: Population growth rate of Lake Dianchi Watershed for every decade (%); GDP: Gross Domestic Product of Kunming City (10^8 yuan); WQ: Water Quality Grade of Lake Dianchi according to Environmental quality standards for surface water (GB 3838-2002) of China. * specified year as 1962.

However, the ascendency of economical development could not gloss over the embarrassing condition of water quality. The Water Quality Grade (WQR) was Grade I in 1950 and 1960, Grade II in 1970, Grade III in 1980, Grade IV in 1990, and finally in 2000, it was worse than Grade V. The unremitting deteriorating water quality has changed the function of the lake. In other words, the lake is bearing more and more socio-economical pressures during the 50 years. It's rational as the pollution loads are growing beyond the lake's carrying capacity. As a result, the water quality is descending quickly.

3 The Relative Water Quality

3.1 Comparing with Economy

Relative Water Quality (RWQ) is introduced to express the interrelationship between water quality and Social or Economical Development. In order to demonstrate the relationship between water quality deteriorating and economical growth, a new index called Relative Water Quality is introduced, which is defined as:

$$RWQ_e = \frac{W}{E} \tag{1}$$

Where RWQ_e is Relative Water Quality versus Economy, where the water quality is expressed associated with economy. W means some certain indicators of water quality, while E is delegated as an economical indicator, such as Gross Domestic Product or alike.

3.2 Comparing with Population

In like manner, the water quality associated with population capacity is called RWQ_p, which is defined as:

$$RWQ_p = \frac{W}{P} \tag{2}$$

Where the RWQ_p is Relative Water Quality versus Population, where the water quality is expressed associated with the social development. The meaning of W is the same as above. And P is a kind of population indicator.

4 Results and Discussions

4.1 Water system of Lake Dianchi

The Lake Dianchi lies in the south part of Kunming City, and the water body is comprised of two parts: Waihai (in the south) and Caohai(in the north). The Kunming City is linking the north part of Lake Caohai. There are several contributing rivers go through the city zone, which could receive a heavy load of municipal wastewater. The main four rivers are: (1) Chuan Fang He (CFH) River; (2) Xin Yun Liang He (XYLH) River; (3) Pan Long Jiang (PLJ) River; (4) Lao Yun Liang He (LYLH) River.

These four rivers are representative of urban pollution. As the Caohai is in the north part, it receives more pollution load than Waihai. Besides, the volume of Waihai is larger than Caohai. As a result, the water quality of Waihai is better than that of Caohai. Next, the RWQ of the four contributing rivers, the Lake Caohai and Lake Waihai would be discussed.

The original water quality data were adopted from Environmental Monitoring Agency of Kunming City. Here the data are transferred into the mode of yearly average ones. The GDP (10^4yuan) and total population (10^4person) are adopted from the Yearbook of Kunming City, 1991-2008.

4.2 Contributing rivers

For the Four contributing rivers, the water quality indicator of COD is selected to denote their RWQ. For RWQ_e, Gross Domestic Product (GDP) is selected as the economical indicator. Thus following equation(1), RWQ_e is expressed as RWQ-COD-GDP (Figure 1), unit: 10^{-10}mg/(L·yuan). For RWQ_p, following equation(2), total population of Kunming City is selected as social indicator. Thus RWQ_p is expressed as RWQ-COD-POP (Figure 2), unit: 10^{-6}mg/(L·person).

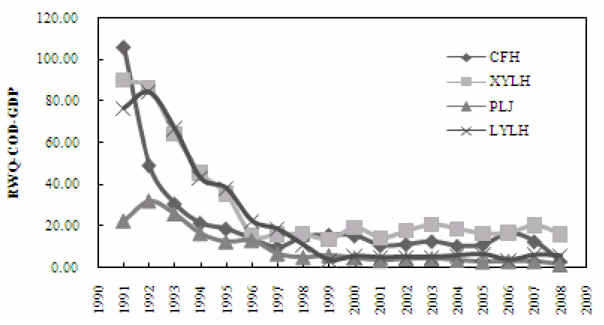

Figure 1. The RWQ-COD-GDP index of several contributing rivers

This .diagram showed an obvious decline of RWQ_e of the four rivers. This could be explained though that the rapidly developing economy is the one of the causations of the water environmental pollution. The pollution is a kind of concomitant incident of economy growth, it might be avoided if more measures are utilized.

978-1-935068-16-7 © 2010 SciRes.

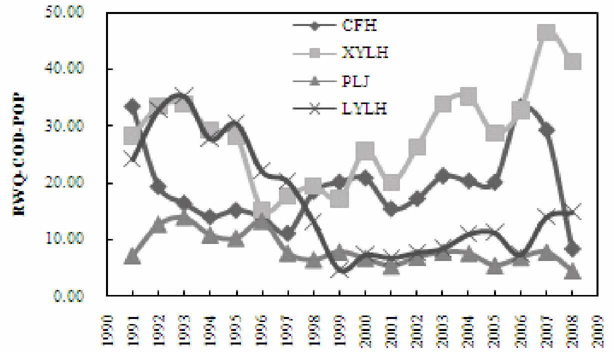

Figure 2. The RWQ-COD-POP index of several contributing rivers

For the four rivers, the tendencies from 1991 to 2008 of RWQ-COD-GDP and RWQ-COD-POP are different, where the former showed a declining trend while the latter is fluctuating.

4.3 Lake Caohai

When water quality is expressed through water quality indicators, such as COD or NH_3-N, while the economical or social indicators remains steady, the RWQ_e for the lake is expressed as RWQ-Y-GDP, while RWQ_p is expressed as RWQ-Y-POP, where Y could be COD, BOD and NH_3-N.

For Lake Caohai, the RWQ-Y-GDP and RWQ-Y-POP are showed in Figure 3 and 4. When Y=COD, the unit of RWQ-Y-GDP is 10^{-10}mg/(L·yuan); the unit of RWQ-Y-POP is 10^{-6}mg/(L·person); when Y=BOD or NH_3-N, the unit for RWQ-Y-GDP is 10^{-11}mg/(L·yuan); the unit for RWQ-Y-POP is 10^{-7}mg/(L·person).

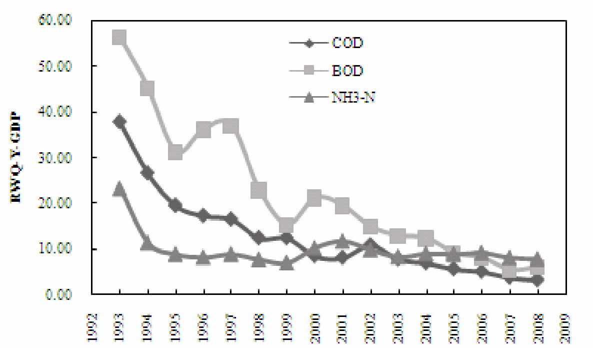

Figure 3. The RWQ-Y-GDP index of the Caohai

The RWQ for Lake Caohai showed a similar trend like the contributing rivers. When considering the difference of economical and social growth rate, the distinction of RWQ_e and RWQ_p could be cast back to it.

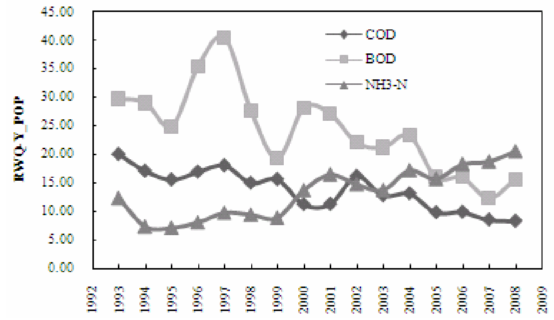

Figure 4. The RWQ-Y-POP index of the Caohai

4.4 Lake Waihai

Analogously, The RWQ of Lake Waihai could be gained in the similar way of Lake Caohai (Figure 5 and 6). All the units of RWQ are the same as those of Lake Caohai, except for when Y=NH_3-N, the unit of RWQ-Y-POP is 10^{-8} mg/(L·person).

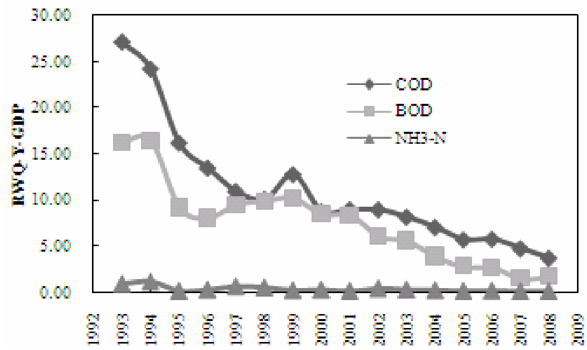

Figure 5. The RWQ-Y-GDP index of the Waihai

The Lake Waihai has a similar condition as that of the Lake Caohai. The only difference exists in the water body volume and relative bigger capability to bear pollution load. The common result is that declination of RWQ_e is more obvious than that of RWQ_p.

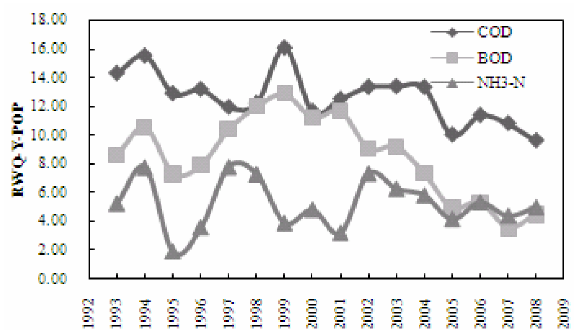

Figure 6. The RWQ-Y-POP index of the Waihai

4.5 Discussions

As is showed above, the water quality of Lake Dianchi changed with the urbanization process. The consideration of economical or social indicators helps to understand their coherence. Although the extents of economical or social effects are different, these two factors are alike when affecting the water quality. So it's important to consider water body eutrophication into urban planning procedure [8].

For Lake Dianchi, due to it borers upon the metropolitan area of Kunming City, compromise among urban planning, land use projects, and water pollution control or treatment are pivotal in protection of the Lake Dianchi. In order to aim at sustainability of the whole watershed and the city, more attention should be paid to find a perdurable way to assort socio-economical development with environmental protection.

5 Concluding Remarks

This paper introduced an index call Relative Water Quality (RWQ) in order to associate simple water quality indicators with some social or economical factors. The result showed that both economical development and population growth are affecting the water quality of Lake Dianchi, as well as its contributing rivers. The urbanization process of Kunming City was a directive inducement for the water environmental pollution. People should find a way to realize sustainable development for the watershed.

Acknowledgement

The authors would like to express appreciations for these funds: (1) "National major Science and Technology Program – Water Body Pollution Control and Remediation" (2008ZX07102-001); (2) National Natural Science Foundation of China (40701066).

References

[1] Paul V. Bolstad, Wayne T. Swank. Cumulative Impacts of Landuse on Water Quality in a Southern Appalachian Watershed [J], *Journal of The American Water Resources Association*, 1997, 33(3), P 519-533.

[2] Rauno Sairinen, Satu Kumpulainen. Assessing social impacts in urban waterfront regeneration [J], *Environmental Impact Assessment Review*, 2006, 26(1), P 120-135.

[3] Liu Yong, Guo Huaicheng, Yu Yajuan, Dai Yongli, Zhou Feng. Ecological–economic modeling as a tool for watershed management: A case study of Lake Qionghai watershed, China [J], *Limnologica - Ecology and Management of Inland Waters*, 2008, 38(2), P 89-104.

[4] S. Kondratyev, T. Gronskaya, N. Ignatieva, I. Blinova, I. Telesh, L. Yefremova. Assessment of present state of water resources of Lake Ladoga and its drainage basin using Sustainable Development indicators [J], *Ecological Indicators*, 2002, 2(1-2), P 79-92.

[5] Jennifer E. Ruley, Kelly A. Rusch. An assessment of long-term post-restoration water quality trends in a shallow, subtropical, urban hypereutrophic lake [J], *Ecological Engineering*, 2002, 19(4), P 265-280.

[6] Gabrielle Bouleau, Christine Argillier, Yves Souchon, Carole Barthélémy, Marc Babut. How ecological indicators construction reveals social changes - The case of lakes and rivers in France [J], *Ecological Indicators*, 2009, 9(6), P 1198-1205.

[7] Fang Lin. Pollution causes and treatment analysis for Lake Dianchi of Kunming City [J], *Science & Technology Industry of China*, 2007, 10, P79-82 (Ch).

[8] Sven Lundie, Gregory M. Peters, Paul C. Beavis. Life Cycle Assessment for Sustainable Metropolitan Water Systems Planning [J], *Environ. Sci. Technol.*, 2004, 38(13), P 3465-3473.