

## Research Article

### A Case Study on Fishpond Water Pollution Control for the Eutrophic Lake Dianchi in China

<sup>1</sup>Ke Huang, <sup>1</sup>Jin Hua Li, <sup>2</sup>Zhu Jing Jin, <sup>2</sup>Feng Le Yang and <sup>1</sup>Bao Xue Zhou

<sup>1</sup>School of Environmental Science and Engineering, Shanghai Jiao Tong University, No. 800 Dongchuan Rd, Shanghai 200240, China

<sup>2</sup>Yunnan Academy of Environmental Science, Kunming 650034, China

**Abstract:** How should the developing areas control the worsening of fishpond water pollution while keeping economy growth on track? The paper tries to provide a useful guideline for other water bodies pollution control in these areas. Based on the local government ruling idea transformation, a new strategy with execution at the core was proposed to deal with the eutrophic Dianchi Lake (DL) of China in paper. The local government changed development model through industrial structure adjustment, laying equal stress on environment and economy. Then, the management level has been effective improved through creating responsibility system for the leaders in charge of DL and its inflowing rivers. Meanwhile, multi-channel investment was strengthened and six comprehensive engineering was implemented for DL pollution control. After several years of practices, fishpond water pollution has been improved greatly and the economy of Kunming still keeps growing momentum during these years.

**Keywords:** Engineering-based treatment, executive power, fishpond water pollution control, market operation

## INTRODUCTION

Fishpond water pollution affects public health and environmental conditions, especially in the developing areas including China. In the past 20 years, many important bodies of water (Xu *et al.*, 2009; Zhang *et al.*, 2011; Kuo *et al.*, 2008) were suffering from eutrophication or severe pollution. Thus, how to control eutrophication and fishpond water pollution are necessary. Many researches (Olaru *et al.*, 2010; Yang and Liu, 2010) have been done in developing areas with limited effect. The essential reason can be attributed to the development model with pursuing economy growth at the expense of environment and inefficient supervision of environmental issues. How to controlling fishpond water pollution while keeping economy growth on track is the problem in the developing areas. Based on a case study of DL, the paper proposes a new strategy with execution at the core to deal with fishpond water pollution with the premise of government ruling idea transformation, improving environmental management.

Despite DL has been treated several decades, the effort only has limited success. The main problems can be contributed to three reasons, including unique geographic location, the development model of local governments with an over-emphasis on economy development and the lack of an effective treatment projects. Since 2008, positive change of government

ruling idea took place. The local development model has been focused on ecological protection, adjusting industrial structure in DL watershed. With this premise, a new management mode by creating responsibility system for the leaders in charge of DL watershed was constructed to strengthen the execution of fishpond water pollution control regulations and policies, aiming to enhance the management quality level. Meanwhile, multi-channel investment was strengthened and a series of engineering was implemented to control DL pollution. After several years of practices, the eutrophic status of DL and its inflowing rivers have been improved. Meanwhile, the economy of Kunming still keeps growing momentum.

## CASE-STUDIES

**Study site:** As one of the largest plateau lakes in China, DL located in the central part of Yunnan-Guizhou plateau and along the division among the three river systems of the Yangtze, Pearl and Red rivers (Fig. 1). It covers 2906 km<sup>2</sup> watershed area and an altitude of 1887.4 m. With a total area of 330 km<sup>2</sup>, the lake body is divided into the small northern Caohai (inner lake) and the much larger Waihai (outer lake). In addition, 35 rivers that located in urban areas flow into DL from north to south, which account for almost 100% of the DL watershed area.

**Corresponding Author:** Ke Huang, School of Environmental Science and Engineering, Shanghai Jiao Tong University, No. 800 Dongchuan Rd, Shanghai 200240, China

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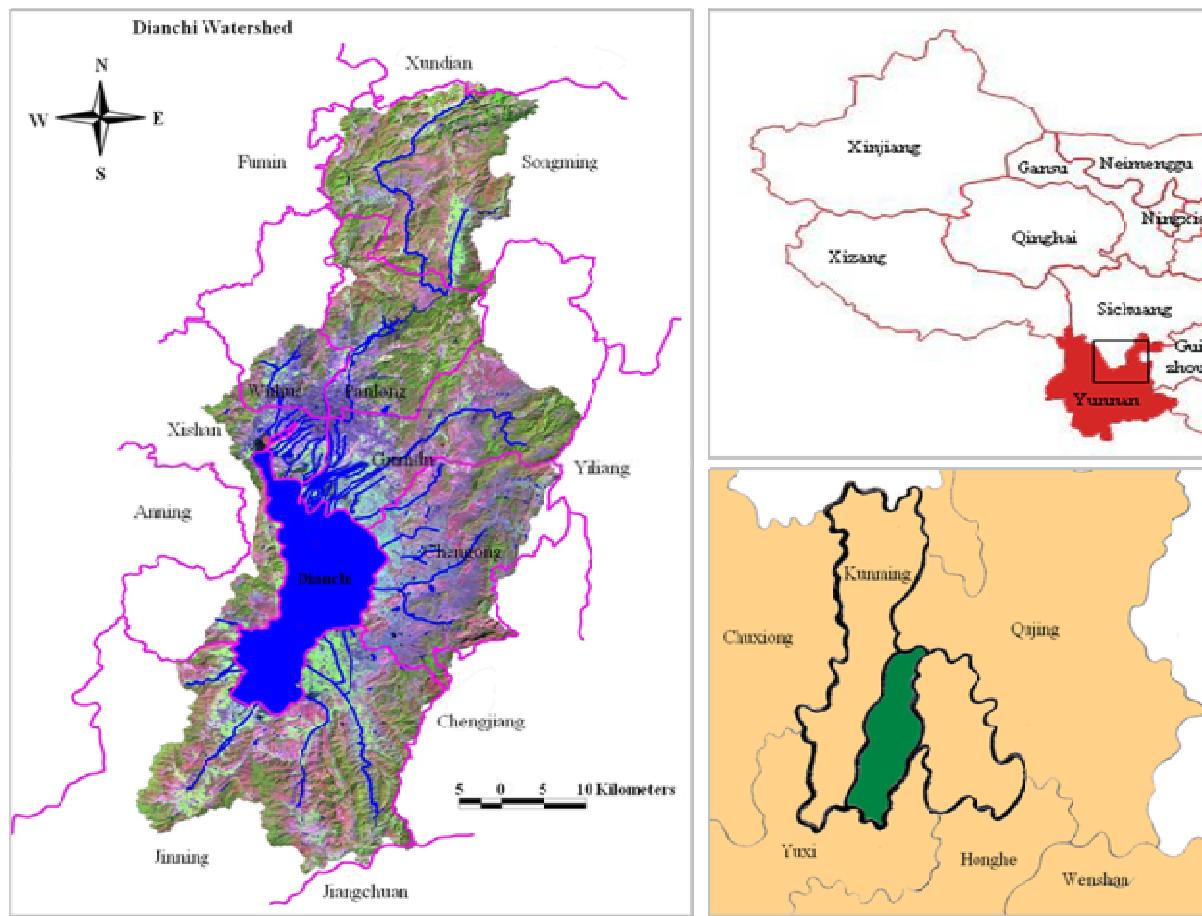


Fig. 1: Map of DL and its watershed

**Changing traditional local development model:** The local government changed traditional development model by industrial structure adjustment. Since 2008, the local government closed down and moved polluting enterprises, or urged polluting enterprises to reform within a prescribed time limit. Meanwhile, it created areas for centralized animal breeding, banned animal breeding elsewhere and regulated animal breeding in counties in DL watershed. In addition, the municipal government changed agricultural lands into forests through the industrial adjustment of 2920 km<sup>2</sup> of the DL watershed. For example, the Kunming government promoted recreational sightseeing agriculture and changed mountainous and semi-mountainous areas into production areas, a mulberry garden for fruits and ingredients of medicine. Furthermore, the government introduced enterprises that built nurseries in DL watershed, thereby establishing the largest park of seedlings in Yunnan province or even in the southwest area of China. The local development model for DL watershed was turned to giving priority to ecological environment thoroughly, laying equal stress on environment and economy.

**Improvement of executive power:** In order to control DL, a series of environmental regulations and many

official organisations were established, including the Dianchi Protection Committee, the Dianchi Administration Bureau and the Dianchi Comprehensive Administrative Law Enforcement Bureau. However, these organizations didn't work well with the traditional development model. In 2008, a new management mode was established by the Kunming government through creating leadership responsibility system and a responsibility-ascertained system in charge of DL and its inflowing rivers that held leaders responsible for dereliction of duty, in a bid to strengthen the function of the government against environmental pollution and improve the executive power for DL management.

**Responsibility system for leaders in charge of DL inflowing rivers:** It is difficult to manage the 35 DL inflowing rivers effectively because the annual average chemical oxygen demand, Total Phosphorus (TP) and Total Nitrogen (TN) from the 35 DL inflowing rivers accounted for 72, 78 and 80%, respectively, of the total concentration in DL. In 2008, a responsibility system targeting leaders in charge of the DL inflowing rivers was implemented including five districts (county) and townships (town, street) around DL for the first time. Municipal leaders served as river leaders, responsible for supervising the effect of fishpond water pollution

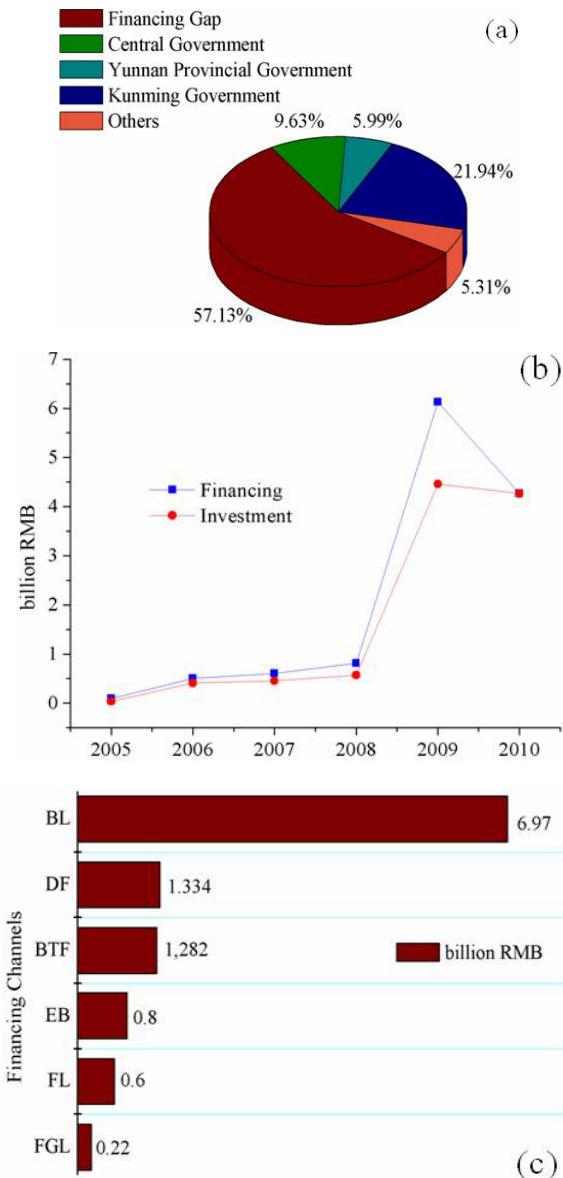


Fig. 2: (a): Investment sources for DL pollution control during 8th to 10th Five-Year Plan; (b): Financing and investment for DL from 2005 to 2010; (c): DL financing channels from 2008 to 2010

control, monitoring water quality, maintaining the cleanliness of water surface and river banks and improving the river landscape by segmented treatment. Water quality data were used to estimate the effect of leader responsibility and were regularly supervised by the media. In addition, a regular inspection system for the 35 DL inflowing rivers was established by the Kunming government in September 2008 to strengthen the enforcement of the system. A centralized mechanism for inspecting was adopted for these rivers twice a month. Meanwhile, a one-vote veto system was strictly implemented, under which the leader in charge of the area where a drainage outlet appears around DL and its inflowing rivers will be held accountable for its

appearance. According to published reports, almost every area has cadres who were blamed under the one-vote veto system. Furthermore, the Dianchi Administration Bureau created a one-on-one liaison system to coordinate the work of these leaders.

**Supervisory system:** In 2009, an effective supervisory system with the aim to ensure DL treating work effective implementation was established by the Kunming government, named the Comprehensive Treatment Headquarters for DL watershed. Many important decisions including investment, engineering planning and local pollution have been solved effectively through Comprehensive Treatment Headquarters. The implementation of a leadership responsibility system and a responsibility-ascertained system has achieved distinct effects since 2008. Within three months of implementation in Dianchi watershed, 224 persons were blamed, 68 persons were suspended, 2 persons were persuaded to resign and 5 persons were forced to resign under the new system. To date, 18 of DL inflowing rivers regulation programs have been inspected completely, including the Panlong, Baoxiang rivers and so on. The leadership responsibility and responsibility-ascertained systems have played an important role in the DL management system.

**Multi-channel financing for DL pollution treatment:** Insufficient funds hampered progress in the control of DL pollution (Fig. 2a) because of limited government investments, social resource scarcity and massive capital demand (YEPD, 2012). Since 2007, with the help of the Kunming government, more government investments, bank loans and introduced numerous financing opportunities were secured via market operations (Fig. 2b and 2c).

**Government Investments (GI):** The central government and the provincial government at different levels invested 4.172 billion yuan from 1991 to 2005 and 5.338 billion yuan from 2006 to 2010 in protection of DL (YEPD, 2012). Bank loans (BL). Several local and foreign banks and financial institutions provided loans of more than 6.6 billion yuan for the engineering-based treatment projects of DL (YEPD, 2008). Foreign government loans (FGL). The German and Finnish governments lent 10 million and 12 million euros, respectively. The government loans mitigated the negative effects of urban development on DL's surrounding environment, thereby decreasing pollution load and saving energy. Enterprise Bonds (EB). DL Investment Co., Ltd. issued 800 million yuan worth of EB for DL treatment. It was the first time for Kunming City and Yunnan province to raise funds in this manner to treat polluted bodies of water (YEPD, 2012). Financial Leasing (FL). The DL Investment Company, Limited collaborated with the Xingye Finance Leasing Company, Limited, to develop a finance-leasing business. It was a first attempt at FL in China, which

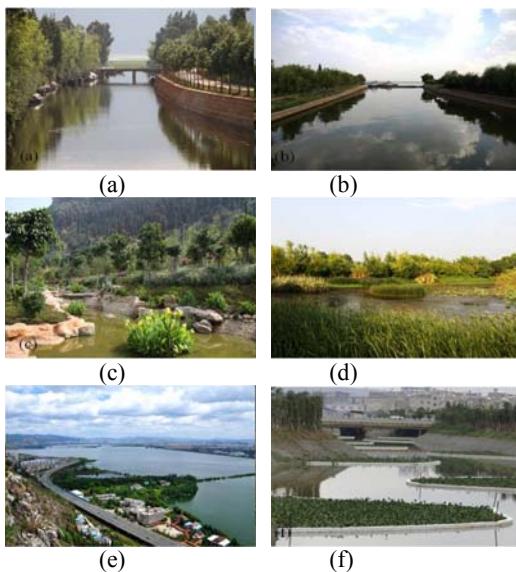


Fig. 3: River after treatment; (a): Panlong River; (b): Baoxiang Rive; (c): lakeside ecological landscape of Shanyi villiage; (d): wetland of Baoxiang River; (e): road around DL; (f): water hyacinth

resulted in 600 million RMB under the gage of pipe network assets within six years. Debt Financing (DF). A debt preservation contract was signed with 11 domestic banks, which was intended to raise the mortgage on the land account receivables or the land pre-mortgage in the Jinning and Yangchang districts, thereby creating opportunities for DF. Build-Transfer Financing (BTF). The 60 million RMB financed by BT channel for the Hai River was used as compensation for land requisition and demolition.

#### **Engineering-based treatment of DL:**

**Comprehensive engineering for DL inflowing rivers:** 35 DL inflowing rivers were treated by various methods including the inspection and closure of pollutant sources, pollutant interception and diversion prohibition of animal breeding on both sides of the inflowing rivers, construction of bridges and roads and restoration of wetlands. To date, 21 inflowing rivers have been treated completely (Fig. 3a and 3b). The water quality of DL inflowing rivers has been improved since 2007 (MEPC, 2007-2011). Furthermore, investment in inflowing rivers in 2008 to 2010 were 551 million yuan, 1.2682 billion yuan and 1.769 billion yuan, respectively, which shown a steady increase trend.

#### **Ecological restoration and construction engineering:**

The engineering restored the DL ecosystem and improved its self-cleaning capacity. Measures included relocating people, houses, farmlands and ponds to the lake, forest and wetlands around the DL boundaries and improving water and soil conservation of the DL watershed and its protected water sources. For example, in the lakeside ecological garden of Shanyi village (Fig. 3c), all villagers were relocated and 40,000 houses were

removed, red clay with 27,000 m<sup>2</sup> area was backfilled and 390,000 groundcover plants were planted. By the end of 2010, 1.67 billion yuan had been invested to restore 33.3 km<sup>2</sup> of the DL watershed. A total 5000 acres of wetland was restored in 2008, whereas 15,000 acres was restored in 2009. The local governments removed 61 enterprises and 24,000 people around DL and returned 45,000 acres of pond and farmland to the lake and forest. In addition, wetlands with 54,000 acres were built on the lakefront. Water and soil erosion were controlled with 167.49 km<sup>2</sup> area. The project improved the ecosystem, ecological restoration ability and landscape of the DL watershed (Fig. 3d).

**Sewage interception around DL and traffic engineering:** The interception system existed on four levels: pieces interception, river interception, towns and villages interception and trunks (pipe) interception. In addition, traffic engineering was regarded as the main carrier for the construction of trunks interception. To date, the engineering project has completed the deployment of an interception system on all the four levels. It laid 96 km trunks, 251 km of main pipe network and 155 km of sub-main pipe network, established 8 plants of rain and sewage treatment with a daily capacity of 1,105,000 m<sup>3</sup> and repaired 114.5 km of road around DL (Fig. 3e). Furthermore, the storm sewers of 1,868 enterprises in the older parts of Kunming city were modified and separated and enterprises around DL were relocated to an industrial park.

**Agricultural non-point source pollution treatment:** A series of measures with industrial structure adjustment at the core were carried out (2.2).

**Ecological dredging:** Ecological dredging significantly reduced the internal pollution of DL by disposing bottom sediment in accordance with a harmless and recycling principle. This engineering project included the farming of aquatic plants (water hyacinths, Fig. 3f) and the regulation of fish resources. The sediment dredging covered a total water surface area of 4,220,800 km<sup>2</sup> and sediment area of 3,700,000 m<sup>3</sup> by the end of 2010, which had an aggregate investment of 220 million yuan.

**Transferring water from outside basin and water saving:** Adequate water resources can alleviate DL pollution. The water-saving engineering has promoted the DL ecological restoration by transferring water from the Niulan River, the primary tributary on the right bank of the Jinsha River. The Niulan River can supply 600 million m<sup>3</sup> of water per year for 20 years and can improve the water resources of the DL watershed and ecological environment. Furthermore, the water-saving project proved effective in terms of the construction of sewage recycling facilities. To date, 162 decentralized facilities for water recycling with a

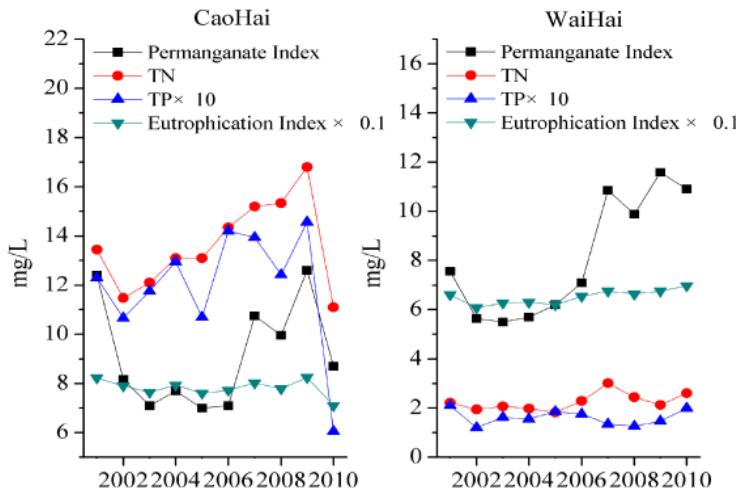


Fig. 4: DL water quality from 2001 to 2010 (YEPD, 2006-2011)

processing capacity of 499,000 m<sup>3</sup> per day and centralized recycling water facilities with a daily water supply capacity of 8,000 m<sup>3</sup> have been built and 110 facilities with a processing capacity of 270,000 m<sup>3</sup> per day are under construction.

## RESULTS AND DISCUSSION

Figure 4 shows that the eutrophic status and water quality of DL have been improved. In Fig. 4, the total amount of major pollutant (except for TN) in Waihai is 0.31 times that of accepted surface water environmental quality. Thus, water quality in Waihai has achieved Grade V or higher. The average TN and TP in Caohai decreased by 13.6% and 48.1%, as compared with that in 2007. The ratio of the water quality standards of 13 inflowing rivers increased from 56% in 2008 to 88% in 2010. Up to now, the strategy continues to be applied to DL watershed. Comparing with the data of 2010, a good effect has been shown in 2011. Comprehensive trophic level index in Caohai and Waihai reduced by 3.79% and 2.83% and other main pollutants reduced at different levels in DL. Meanwhile, the GDP of Kunming City has exhibited an annual increase rate of 12.7% during the 11th Five-Year Plan, indicating that environmental protection and economic development have a dialectic relationship.

## CONCLUSION

A sound strategy for fishpond water pollution control that should conform to the state's actual conditions is necessary. In rapid developing areas, only changing government ruling idea and focusing on the improvement of execution of environmental regulations can polluted bodies of water be controlled. The paper tries to provide a useful guideline for other polluted bodies of water in these areas.

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