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Improve Urban River Water Quality by Integrating Water Resource Management into Urban Construction

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Abstract. Increasing population and urbanization pose more and more threats to urban river. Integrated Water Resources Management (IWRM) is possible framework to solve water resource management problems through cross-sectional cooperation, but the vagueness in this concept make its application difficult. This paper focuses on urban river management practices in China and classified the government-guided cross-sectional urban river management projects to a special pattern of IWRM (GIWRM). It is proved to be effective in synthesizing efforts of different government departments, industry and the public and improve the urban river conditions a lot.

Introduction

Urban rivers are always fragile and threatened by various human social-economic activities.The increase of impervious surface cover within urban catchments, as a result, alters the hydrology and geomorphology of stream. Besides, runoff from urbanized surfaces as well as municipal and industrial discharges results in increased loading of nutrients, metals, pesticides, and other contaminants to streams. These changes result in consistent declines in the richness of algal, invertebrate, and fish communities in urban streams[1].

Water quality deterioration of urban river is a globally universal problem. In highly industrialized countries, through years of pollution reduction and ecological remediation, urban rivers functions better than some developing countries, like China, India, Brazil, but hardly performs as natural state. In the last 30 years, organic pollution in the Seine River has been strongly reduced, but a noticeable decrease of fish species numbers down-stream of Paris is still observed and downstream of Paris, below the Achères sewage treatment plant, massive fish mortality frequently occurs because of low oxygen conditions[2]. The substantial organic and nutrient pollution might have lasted up to very recently in Brussels, when the Brussels Northern wastewater treatment plant began operation in 2007, significantly reducing the organic and nutrient load of the Zenne River[3]. The river Schwippe presents high concentrations of organic pollutants in surface waters during storm events, as industrial and urban pollution can accumulate in the catchment and are only transported into surface waters due to storm events[4]. However, the situation is far more serious in developing countries. It is concluded that dissolved metal, organic and fecal pollution in the rivers of developing countries are in somewhat dreadful condition in comparison with the rivers of developed country by a study of rivers in Dhaka, Bangladesh; Hokkaido and Osaka, Japan; Erdent, Mongolia and West Java, Indonesia[5].

Positive aspect of urban river water quality issue is that since 1990s researchers gradually confirmed and modified the hypothesis of environmental Kuznets curve (EKC) rendering an inverted U curve between environment quality and economic growth. EKC proposes potential of tackling environmental problems by sustainable economic development and environmental pollution will decrease finally when the income per capita reaches the turn point of EKC. In developing countries like China, because of adoption of EU or US environmental standards and technologies, the turn point of EKC is earlier than expected[6]. Some urban river regulation practices in China, are examples both of IWRM and EKC.These projects may combine with other municipal projects, but all these urban construction projects together forms a Chinese Style of

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government guided IWRM (GIWRM) by planning and constructing water resource, environmental, and living facilities together.

The aim of this study is to categorize this kind of GIWRM methods, achieving environmental effects before the EKC turning point through integrating urban river protection into new city construction, find the prerequisites and application for this method, and draw experiences and lessons for other developing and urbanizing cities in the world.

Integrate Urban River Protection into Urban Planning and Construction

The increasingly complicated and intercrossed water problems cover water quantity, quality and water availability. IWRM is a structural concept of cross-occupational cooperation and bridge between researchers, engineers and government employee. But the definition of IWRM continues to be amorphous, and there is no agreement on fundamental issues like what aspects should be integrated, how, by whom, or even if such integration in a wider sense is possible.

Consensus is IWRM consists of management in urban development, environmental protection, water supply, agriculture, etc. A bulletin of management measures should be considered together to ensure the high use efficiency of water resources. Area around the river is taken as an individual object and river management and conservation, real estate construction and wastewater treatment are planned and conducted together. Some significant and effective measures for urban river protection are successfully conducted, includes nearby factories relocation, separate drainage system construction and wastewater treatment capacity improvement. These measures have largely improved urban river conditions in these cities.

The category of urban river management projects in China should be classified as a special integrated management mode (GIWRM). GIWRM means that guided by government, through the active participation of enterprises and other economic entities under government-led framework, urban rivers are emphasized in the new regional development and protected even just for satisfying the increasing environmental requirements of the new city region and city habitants. However, the numerous political and economic resources input in this mode ensure the unimaginable effects of river management than river management by water professionals alone. Qinhuai River management in Nanjing is taken as an example of GIWRM mode as follows.

Nanjing is the capital of Jiangsu province in eastern China, which is part of the downstream Yangtze River drainage basin. Nanjing has a humid subtropical climate and is under the influence of the East Asian monsoon. The Qinhuai River is the major river that runs through central Nanjing. As the population in Nanjing grows and Industry develops, Qinhuai River becomes heavily polluted since the 1980s. In 1989, the COD in Qinhuai River is 17.5-106.7mg/L in different reaches, and Volatile Phenols 0.0399-0.0750 mg/L, oil 4.7-21.5 mg/L,and NH_3-N 6.7-18.35mg/L, classified to heavily polluted level. Industrial and living wastewater is major pollution sources.

The local government has conducted five large scale Qinhuai River Management projects since 1949. The earlier three projects between 1952 and 1980 aimed at flood control, drainage, water supply and shipping, so even though the river has been polluted seriously at that time, the water quality issue is not emphasized enough. This management pattern was decided by urbanization and economic development phase before 1980. Since 1949, the characteristics of Chinese urban development are transformed from a consumption-oriented city to manufacturing-oriented city.In addition, because the economy was still in the period of extreme expansion, investment in river dredging and water conservation is far from enough. Urban river water quality and environment were considered and water pollution control was in the agenda in 1980s.Water quality management gradually became the main concern since 1999. The motivation may be concluded to the rapid economic development since the revolution and open up policy. The foundation of these projects was the 5000 million RMB input in Qinhuai River management and development, 50 times that of the earlier three management projects. Without rapid economic growth, such investment is certainly impossible.

The bulletin of urban river management measures includes making river management top priority of city construction, factories along the river relocation, Wastewater treatment and separate sewage system, and habitants relocation.

Making River Management Top Priority of City Construction. River management cannot succeed without coordinated efforts of other municipal departments, civil, traffic, communication, industry. Thus it is very important that what priority is river management in the city construction. The priority of Qinhuai River water quality improvement promotes GIWRM of this river, and GIWRM also recognizes river management top priority during city construction. Qinhuai River water quality become graduallyimportant since the housing commercialization motivated large-scale urbanization or the new city construction movement in the mid 1990s. And the 10th National Games of China in 2005 held in Nanjing was also an important stimulus. Since 2002 , Nanjing Government decided to construct the new city of Hexi region, and also start Qinhuai River integrated management project. The official goal was "let beautiful river become beautiful river, flowing river and bustling river". The improvement of the Qinhuai River management project priority in government agenda should not be purely reasoned to stronger financial ability to pay or changing idea of pollution control, but to that the central task of urban construction has changed, or the government at different times faced different political mission. It is rapid economic development that led to the ancient city like Nanjing to build a tourist city, enhance the overall image of the city, attracting foreign and domestic guests, and thus begin the campaign against pollution.Dredging, water rushing, treatment of industrial and hospital waste, laying interceptor sewer and construction of urban sewage treatment plants and other means to control pollution in Qinhuai River were together used striving to reproduce the ancient beauty and prosperity along the river.

Factory Along the River Relocation. In the past, factories near Qinhuai River release wastewater directly into the river, seriously damaging river water quality. Since 1992-2004, a total of 221 factories were included in the relocation of polluting enterprises in Nanjing. After years of efforts, 192 factories includeing the Nanjing Cigarette Factory, Nanjing Automobile Group, Jinling Pharmaceutical and Wuzhou Refrigeration Group have relocated to new industrial region far from the river. Though relocation of polluting enterprises was results of government unified planning and force execution, economic motives cannot be ignored. In order to encourage the relocation, the government launched the market leverage to create favorable conditions for enterprise relocation, formulated a series of policies to promote these policies mainly related to land, corporate relocation funds, taxes and so on. In terms of land policy, relocation of polluting enterprises can be viewed as infrastructure projects or a technical upgrading project and expand to 130% of the gross floor area than that before the relocation. After two years, this favorable policy increase to 150%. Moreover, the original factory site can be used by the company for business, trade and other tertiary industries. All these measures make great influence in factory site choosing and decrease industrial pollution along the river significantly.

Wastewater Treatment and Separate Sewage System. Although the pollution control reduces industrial and living contaminants into Qinhuai River, improving the wastewater treatment capacity is still main measure for water quality improvement. In 2013 to 2015, Nanjing plans 28 wastewater treatment plant, making the total treatment capacity to 2.7 million ton per day. Separate sewage system for rainwater is under construction now for avoiding wastewater directly poured to the river because of the insufficient wastewater capacity. However, recent study on combined and separate sewage system also reminds of treatment for rainwater [7]. To conclude, wastewater treatment and sewage system is still quite important to cycle water in urban area.

Habitants Near the River Relocation. The river bank area performs important ecological function in a river. Habitants in Nanjing encroached river even to 20 metres from the river side. To better protect Qinhuai River, since 2004, local government has established the Qinhuai River integrated environmental management bureau of high level. In about two years, the total length of 12.5 km regulation district from the estuary to Yangtze River to Wudingmen sluice in the upper reach, completed a total area of 380,000 square metres demolition, the relocation of 4,356 residents, the relocation of 97 enterprises; approximately 20 km demolition of old flood wall, more than 10 scenic spots, renovation of 110 buildings along the river, 13 new bridges and a total of one million square metres of green area were accomplished at the cost of 2500 million yuan. So far, pollution control movement by state power was completed in almost all the related aspects of Qinhuai River, also as a postcard of the city.

The volume of these indicators are rather low or even not detected in the detection limit level, suggesting that the river basin relocation of industrial pollution a success. By laying interceptors, sewage wastewater collection as well as the construction of sewage treatment plants, such indicators that reflect the organic sewage pollution as IMn, BOD5 and petroleum have reached or almost reached GB3838-2002 "Surface Water Quality Standards" to Grade Ⅴ, meeting the basic needs of the general landscape features of Qinhuai River. Water diversion projects and dredging also makes a steady return of dissolved oxygen in water bodies. The black and smelly water phenomena greatly changed. But indicators reflecting the tertiary sewage and pollution such as NH3-N reduced slowly, as a result of insufficient wastewater treatment capacity. The major pollution source shifts from industrial pollution to living and commercial pollution. And without heavy rain, water quality of Qinhuai River is relatively in control.

Conditions of GIWRM Mode

The GIWRM mode above successfully integrate various resources in water resource management and present good effects on water quality improvement in China. So what are the conditions of this GIWRM? Three basic conditions are concluded as good government management ability, certain economic basis for environmental protection input and good public environmental conscious.

Good Government Management Ability. IWRM needs cooperation of different departments of industry and government. GIWRM is a bigger challenge for government. The overall Qinhuai River pollution control process reflects the state-led force. In fact, large-scale water conservancy projects in any dynasty of Chinese history are results of state power. And in the modern industrialized countries, environmental pollution control is also national or local government concern. In both the cases of Seoul Cheonggyecheon restoration and lute lake near Kyoto, Japan, state and local governments have played a positive promoting or dominant role. However, in China, specifically in the Qinhuai River pollution, the dominant role of the state or local governments, not only reflects in aspects of finance, manpower recruitment and the specific implementation of the management plan, funds, but also in control of the social conscious including pollution issues, including the formation of the original free and open market forces and motivating economic development, and even in the direct political mission of government.

Economic Basis for Environmental Protection Input. The rapid industrialization phase of economic development is often characterized by high pollution and energy consuming. Environmental protection such expensive option for government to take for some developing countries. Even good planning and sustainable development can mitigate this problem, but environmental protection can hardly develop as fast as economy in high speed developing countries. Moreover, environment protection needs financial inputs. So the 50 times of input of new Qinhuai River Management projects and the positive effects remind us of the economic basis for better environment. This is not to defend for environmental pollution. But indeed poverty tends to lead more serious problems even in tribes of the traditional life styles in latin America or Africa. In this way, EKC is still a meaningful hypothesis viewing development and environment.

Public Environmental Conscious. In the vision of many sociologists, social issues become issues only when related subjects have a subjective awareness of this fact. The Qinhuai River pollution hasn't become a social issue until recently. Urbanization process decreased human dependency on river and the industrialization process emphasized economic development and ignored the environment problems accompanied. Economic growth improves public conscious of environment issues. Yangzi Evening News in 1986-1995 published 49 articles and reports about the Qinhuai River, and only 16 of them involved the theme of water quality or wastewater treatment. Public attention to Qinhuai River appeared in 1990s after a relatively open environment for the media, especially the non-party newspaper and television evening news advocating for people's better livelihood. The 1993 founded "Jinling Evening News" for example, in the eight years between

1996-2005, have totally 319 reports about the Qinhuai River. The raised public environmental conscious not only pushes government to stricter water regulations but also gradually improve habitants' water use habits.

Conclusion

IWRM is only a concept, not a solution. The GIWRM in China make progress in urban river management and water quality improvement, but still a lot need to be done. Through GIWRM, living and service industry become the major water pollution sources. Future urban river water quality management requires better residential wastewater treatment, raised public awareness of water conservation, improved sewer network, separate rainwater and wastewater sewage system to cope with the current deterioration of water quality at raining time. Urban river water quality cannot be improved by traditional hydraulic and environmental ways. Integrating urban river management into urban planning, building city space a synthesized system of coordinated living space, water cycle, and waste and wastewater treatment is the direction to better city living experience.

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