

Strategies to water pollution control in western China^{*}

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Abstract: Problems of and main limiting factors to Chinese western eco-environment are analyzed firstly and principles of integrating water pollution control with water resources planning and management, with ecological construction and with economic development planning and setting control priorities according to local conditions are proposed. Following strategies for water pollution control are suggested: 1) a master plan for western area need to be established as soon as possible; 2) total emission control should be regarded as the basic policy and measures such as clean production, charging and subsidy need to be implemented; 3) point sources pollution control should be considered the main task in short term and centralized wastewater treatment plants by using sustainable processes should be constructed primarily for large and medium-size cities with heavier pollution; 4) sound institutional and regulation systems need to be established to create an enabling environment; 5) multiple investment system should be established; and 6) studies of pragmatic theories and methodologies for water pollution control and cost-effective technologies appropriate to western area, and training of local technicians need to be enhanced as well.

Keywords: China; western areas; water pollution control; strategy

1. Introduction

Western Development was proposed by the Chinese government as a key strategy in its 10th five-year plan to advance Chinese overall economic development, regional equilibrium and social stability in the 21st century. A heavy burden on the natural resources and ecological environment in the western areas can be foreseen and water pollution control need to be given special attention. Covering a total land area of 6 880 000 km² (about 71.1% of the country) and having a population of 35.5 million (about 28.5% of the country), the West is generally divided into two main parts that have very different natural conditions, the Southwest and the Northwest. In contrast, the latter has much lower water than the former, counting as only 18% of the total water availability (about 1500 billion cubic meter) in the West, while occupying 57% of the total land area. In general, the Northwest is extremely arid but has quite abundant land and the Southwest has abundant water but with relatively abstraction difficulties because of high elevation difference from water sources to use terminals.

Based on the 2000 environmental quality report of China State Environmental Protection Agency (CSEPA) (2001), water quality was good in general in the western area as a whole. However, water pollution in several waters, especially along the urban reaches, was rather severe and a trend of heavier pollution was

appearing. E.g., there were 13 monitoring sites around Dianchi Lake in Kunming City that have water quality incompliant with category V standard of "Environmental Quality Standard for Surface Water", and the pollution in Grass Sea Lake of Dianchi was much more extrusive than that in previous years; the urban reaches of Huangshui River, Wei River and Fen River, which are all the branches of Yellow River, were also under severe pollution. Backwardness and insufficiency of environmental infrastructures—drainage pipes in many cities are deteriorated and out of service and in most cities, there is no any wastewater treatment facility at all—is of course the leading cause of the above mentioned water quality situation, but there are also many other important limiting factors.

2. Limiting factors to western water pollution control

2.1 Complex natural condition.

The natural conditions in geology, topography and so on are very complex in southwest. Mountains, hills and rivers flowing through them divide many urban areas into several independent segments and make land use very difficult. Many areas are with steep slopes, resulting in another difficulty in land use. E.g., in the Three Gorges Reservoir region, only 14.4% of the total land area are plain and the rest are all sloping lands, and more than 25% are even with slopes steeper than

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^{*} Part of the achievements of the project supported by Chinese National Natural Science Foundation (No. 59838300)

25°[1]. Besides, geological disasters such as landslide and debris flow took place very often. All these make land use difficult and construction cost of wastewater facilities very high. Land use in northwest is much better, but climate makes for other difficulties: the high seasonal and diurnal temperature differences are unfavorable for microorganism growth and metabolism; and high percolation capacity will also bring difficulties to water pollution control facilities design and construction.

2.2 Low social and economic development level.

The society and economy in western areas has been underdeveloped historically. Disparities have increased and seem to be still increasing. The increase rate of gross domestic products (GDP) in the West was lower than the national average level, so was the per capita income[2,3]. More dangerously, the low development rate was maintained at the cost of overexploitation of natural resources and deterioration of natural environment, resulting in the reciprocal causation of poverty and environmental devastation [4]. The urbanization level was reported to be lower than the national mean level [5] and the required physical infrastructures for water pollution control are lacking. Information obstruction and conservative thoughts are other problems to water pollution control.

2.3 Low technological level and research capacity.

Obviously, the low socio-economic level will result in low technological level and scientific research capacity. There is a higher percentage of uneducated people in the western area than that in middle and eastern regions of China and this poses a potential negative impact on maintenance of drainage facilities. It has been often observed that the residents along the street poured sewage into storm water drains and made two separated drains to two combined sewers, and thus degraded their environmental function. Low environmental awareness like this is very common in the whole western region.

2.4 Incomplete environmental institutional system.

Lacking a perfect environmental institutional system is another big common problem in the western areas. A framework of organization with an effective and active human resources system, smooth information sharing and communication, sound relationships with other departments and local government and an institutional performance assessment system is lacking in the West. As one of the consequences, there is almost no successful charging and monitoring system, especially

in medium and small-size cities. Under the pressure of reducing poverty and developing economy, water pollution control is always out of concern of the municipal leaders.

2.5 Bad urban decision-making environment and Low-level urban planning and management.

Backwardness is often accompanied with incomplete urban decision-making process and imperfect environment as well as low-level urban planning and management. This is particularly true for most western cities. Economic development projects are often determined without deliberate discussion and study of their environmental impacts by different departments. And urban planning is often done and approved according to local officials' wills instead of local real condition. Too large city size and bad urban construction management are often observed. Urban drainage system and wastewater treatment plants (WWTPs) are not given due concern in urban master plans, and rationality of the master plan per se is doubtful. The situation seems not to be changed in the near future.

2.6 Uneven distribution of natural and socio-economic condition and unreasonable urban hierarchy.

The economy and its growth pattern, social system, natural geological condition and climate, living styles of different folks vary much throughout the western region and even within one city. Furthermore, urban hierarchy of large-scale cities, medium-size cities and small cities and towns is not in a good proportion and their leading role both in economic development and water pollution control is hardly realized. These factors make it difficult to implement integrated planning and management.

3. Strategies to water pollution control in western China

3.1 Principles

3.1.1 Integrating water pollution control with water resources planning and management.

In Chinese western areas or even in whole China, water pollution control and water management are charged by different departments, meaning that water quantity and water quality are isolated from each other. Consequently, urban sanitary facilities always lag behind water supply. In recent two years, comprehensive methodologies have been adopted both in water pollution control and water resources planning & management, but without interdepartmental sharing,

much information are repeatedly constructed and policy conflicts are often created. It is very necessary to integrate water pollution control with water resources planning and management. It also means that upstream water and downstream water should be planned and managed comprehensively.

3.1.2 Integrating water pollution control with ecological construction.

The water and ecology in western areas are with much closer relationships than in other Chinese areas. Ecological environmental construction and water pollution control are closely interlinked. On one hand, the vulnerable ecological environment makes it sensitive to water pollution, and once destroyed, it is hard to be restored. The monitoring results at upper Yangtze River reaches indicated that water quality deterioration has endangered the existence of rare fish species and aquatic ecological diversity [6]. And on the other hand, ecological construction will play an active role on water pollution control especially on non-point source pollution, and some wastewater treatment processes per se are ecological systems. So water pollution control should be integrated with ecological construction and arranged altogether.

3.1.3 Integrating water pollution control with economic development planning.

Traditionally, natural resources and environment are regarded as external factors of economic system by most economists and policy makers, and their intrinsic value and renewal capacity are consequently neglected, which is perhaps the main cause of serious environmental problems and natural resources scarcity. This is particularly true for Chinese western areas where an urgent economic development is desired at present. However, natural resources are in fact essential assets, and some scholars even called them 'natural capital' and thought that they should be invested in as to ensure their stock and recycling capacity [7]. Water is one of the most important 'natural capital's and so should be considered an integral part of economic growth. This may be the only way that water resources can be protected successfully. Integrating water pollution control into economic planning process has two interrelated sides: 1) the impact of economic development activities on aquatic environment should be assessed and the cost for eliminating the impact should be put into the whole cost-benefit analysis, which is the internalization of environmental externalities; and 2) the impact of water pollution control projects on national macro-economy should be assessed too, and bad debts and overburden to urban

residents should be avoided as can as possible. This principle will bring the economic benefits and the environmental benefits together.

3.1.4 Highlighting important tasks and areas according to local condition, and planning with long-term view while implementing phase-by-phase.

As regional uneven distribution exists and available capital is limited, problems in various western areas are certainly with unequal position of importance. The areas that are very important, seriously polluted and easy to control should be highlighted according to local conditions and control measures should be implemented preferentially there. Just as economic development is a long-term task, western water pollution control should be considered a long-term task too and not be expected to be achieved soon. A long-term plan is necessary and ought to be implemented phase-by-phase.

3.2 Strategies

3.2.1 A master plan of water pollution control for western region should be worked out firstly.

In 1999, the State Council issued "A Plan of Statewide Ecological Environment Construction" and provided a basis for western eco-environmental construction and water pollution control. But it is insufficient to guide detailed practices. It is suggested that a special master plan of water pollution control for western region as a whole, which includes general control goals, implementation procedures and priorities and key technological policies, need to be worked out. Interrelationships such as long-term vs. short-term; upstream vs. downstream; watersheds vs. administrative divisions; and management vs. treatment, should be handled and harmonized. The plan may include several levels, and the cities need to draft their own in accordance with the master plan of water pollution control and their own urban master plan. Make full use of aquatic assimilative capacity should be paid attention to in the Southwest to less water pollution control investment.

3.2.2 Total emission control should be adopted.

End-of-pipe management was proved to be inefficient and non cost-effective and source control should be substituted for it. Clean production is advocated and those industries with heavy pollution but low gains should be closed. New ones with similar characteristics should be forbidden. The incorrect thoughts that Western Development is resources exploitation should be absolutely avoided.

3.2.2 Putting focus on point source pollution control and making a compromise to non-point source pollution in the short term.

The main water quality problem is organic pollution along urban reaches, so point source pollution should be controlled firstly, especially for those relatively large cities with better economic condition. As an effective measure, centralized WWTPs should be constructed in these cities, and in order to make full use of their environmental function, secondary drainage networks and interceptors should be built too to avoid that the WWTPs couldn't reach their design scale even after being built for many years, which is a very common phenomenon all over China. Sustainability is advocated as the leading criteria for selecting and designing wastewater treatment processes [8]. It means that: 1) the capital investment and energy & resources consumption should be appropriate to local economy, society, resources and environment and their future development; and 2) the process itself can be easily constructed by stages, modified or extended with changes of aquatic environment quality, functional objectives and general water pollution control strategies, or the units can be re-assembled to have operation manner altered to remove different pollutants at corresponding stages. And for the drainage networks, separate system shouldn't be necessarily regarded as the only drainage system, no matter for newly built systems or re-built systems [9]. Of course, non-point sources should not be neglected. But as available capital is limited and it is harder to control, non-point pollution must not be regarded as a main task in near term. Though physical treatment facilities are infeasible at this period, other policy and regulation measures such as solid waste management, irrigation management, air pollution control and ecological construction can be implemented to enhance non-point water pollution control indirectly. Farmyard manure is advocated to substitute for chemical fertilizer for nitrogen and phosphorus control. Storm water on-site collection, storage and use is an excellent alternative to both water availability increment and non-point pollution control. It is also an effective way to alleviate the impact of combined system on the operation of wastewater treatment plants.

3.2.4 Institutional system construction.

Sound institutional systems that can create positive incentives are very important to sustainable use of

infrastructures, sometimes may be the ultimate limiting factor in developing countries. Under non-enabling institutions and incorrect incentives, construction of infrastructures may result in bad debts and/or undue heavy burden to urban users, and especially in resources deficient countries, wastes of resources resulted from unsustainable run of infrastructure are the most disruptive [10]. The Technical Advisory Committee of Global Water Partnership (2000) [11] also reckoned that establishing an enabling environment would be very essential to implement integrated water resources management. Our own experiences in implementing the World Bank loan utilized Chongqing Urban Environment Project (CUEP) have revealed that the unreasonable institutional systems in Western China, which create poor information sharing and inaction on project design, construction, operation and maintenance, would always delay the project construction period and result in non-sustainability. Current institutional systems in the west with monopolar, top-down decision-making process are inappropriate to attract, utilize and manage both foreign and domestic investment and should be supplemented by multi-centered, bottom-up decision-making process. The effectiveness and timeliness of water pollution control should be achieved by institutional system analysis and performance assessment. Establishing a sound water pollution control institutional system also depends on an overall institutional environment of regulation and urban decision-making, and bureaucracy of municipal government should be avoided as well. Institutional reforms for integrated water management have been undergone in eastern areas, but haven't been carried out successfully in most western regions. It need to be promoted immediately.

3.2.5 Establishing multiple fund raising approaches.

Fund insufficiency is a key and realistic bottleneck to water pollution control in the western areas. To solve this problem, multiple approaches for capital raising should be established. Firstly, the central government should establish a special fund to implement large interregional projects as financial compensation of development cost. Secondly, foreign capitals, local loans and funds and private capitals should be welcomed and need to be well administrated. Finally, a wastewater charging system should be well designed and established to raise both investment capital and operation & maintenance (OM) cost and to enhance

sustainability of the facilities. However, charge and subsidy should be balanced carefully because there are large amounts of impoverished families in the western region. Creating positive incentive is the leading criteria for charge rate setting.

3.2.6 Enhancing scientific researches of planning and management theories for water pollution control and cost-effective wastewater treatment technologies appropriate to the West, and providing more technical training opportunities.

Special research funds should be provided by the government to enhance scientific research and to promote overall technological levels of local technicians. The role of local universities and institutes in water pollution control should be improved and enhanced. And the training of local technicians need to be enhanced as well.

4. Conclusions

As the ecological environment in the western areas is vulnerable and wastewater facilities are highly insufficient, water pollution control should be considered an important integral part of the West Development strategy. With the limitations in all of natural, socio-economic, financial, institutional and educational aspects, a general strategy is urgently needed. In principle, water pollution control should be integrated with water resources planning & management, ecological construction and economic development planning and implemented by phases and with differentiated priorities. At present, a master plan taking total emission control as the basic policy for western area as a whole need to be established primarily. Point source pollution control is considered the main task in short term and centralized wastewater treatment plants by using wastewater treatment processes with high sustainability should be constructed in those large and medium-size cities with heavier pollution and better economic condition. In addition, sound institutional system and multiple investment approaches should be established.

Researches on appropriate and pragmatic technologies and local forces should be enhanced as well.

Acknowledgment

This paper is part of the achievements of the project supported by National Natural Science Foundation of China (No. 59838300).

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