



# Analysis on the Current Status and Regulatory Measures of Water Pollution in the Xiang River Basin of China

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## ABSTRACT

Water pollution in the Xiang River Basin of China is exacerbated by continuous population growth, rapid economic development, and accelerating urbanization. Abundant pollutants from various sources significantly degrade the basin's water quality. The degradation of water quality influences the economic and social development in urban agglomeration along the basin. To analyse the current status and explore appropriate regulatory measures of water pollution in the Xiang River Basin of China, this paper discusses causes, current status and variations of water pollution in the Xiang River Basin based on the 2002-2015 statistical data of urban agglomeration and environmental pollution in the basin. Results demonstrated that the Xiang River basin is moderately polluted. The majority of the basin's water bodies are polluted at the III-level. Approximately 70% of total pollution in the basin is contributed by III-level, IV-level, V-level, and inferior V-level pollution. Large-scale industrial wastewater drainage, extensive pesticide use, urban sewage pollution, and ineffective government control measures are the main causes of water pollution in the Xiang River basin. Water pollution in the basin has the following characteristics: 1) water pollution is becoming increasingly complicated; 2) industrial waste gas and atmospheric pollution intensify water pollution; 3) degradation of ecological and environmental functions causes abnormal self-recovery of the water body; 4) large-scale exploitation of mineral resources intensifies water pollution. Water pollution in the Xiang River basin can be effectively improved by perfecting the legal constructions of scientific decision, administrative organization, and public participation. Results in this paper can provide scientific and accurate references to understand causes and current status of water pollution in the Xiang River basin, to continuously increase the regulation level of water resource management, and to help related departments in the continuous utilization and optimal configuration of water resources in Xiang River.

## INTRODUCTION

Recently, China has achieved notable development in national economy, industrialization, and urbanization. However, China's water resources are continuously deteriorating. Serious water pollution significantly affects people's daily lives. Therefore, China advocates constructing a "resource-economical and environmentally friendly" society and ecological civilization for sustainable resource development. However, seven major water systems in China are polluted to different extents. Basin pollution is the main characteristic of water environmental problems and has become a major constraint to China's construction of an environmentally friendly society and ecological civilization.

Xiang River is the second largest tributary and is in mid-stream of the Yangtze River. The Xiang River basin is crucial to the economic, social, and cultural development of Hunan Province. The basin is a region with the highest urbanization level in Hunan province, and the total basin area accounts for 43% of Hunan Province. The population and

GDP of the Xiang River basin account for 60% and 75% of those of Hunan Province. Meanwhile, the basin bears more than 65% of the water pollution in the province and is suffering from serious heavy metal pollution. Given the sharp population growth in urban agglomeration, accelerating urbanization, rapid industrial development, and extensive agricultural fertilizer and pesticide use along the Xiang River basin, many synthetic substances, including oils, acids, alkali, heavy metals, radioactive substances, fluorides, and phenols, are discharged into the water body and cause water pollution. Although water pollution in the Xiang River basin has improved to some extent after years of control, the governance process is still problematic. Currently, water pollution control in the Xiang River basin is not in a good state. Laws and regulations on water pollution control fail to achieve the expected control effect because of certain deviations. Therefore, analysing the causes and current status of water pollution is necessary and urgent to propose effective, law-based water pollution control measures for the Xiang River basin.

## EARLIER STUDIES

Research studies on current status and regulatory measures of water pollution around the world are abundant. Karn posited that rivers in Bangladesh, India, and Nepal suffer from serious pollution caused by mass urban sewage emissions (Karn et al. 2001). Meng briefly introduced the environmental status of China's river basins and discussed the main problems in water pollution control and in comprehensive water environmental management of basins (Meng et al. 2004). Gunkel analysed the water quality changes of Pojuca River and found that water pollution is mainly caused by upstream inputs from domestic sewage and sugarcane planting and processing (Gunkel et al. 2007). Aiping analysed water pollution and pollution source status in the Yellow River irrigation area in Ningxia, China (Aiping et al. 2010). Azizullah proposed that water pollution is one of the main threats against public health in Pakistan and that human activity, such as the improper disposal of agricultural, municipal, and industrial wastewater and pesticide abuse, are the main causes of water degradation (Azizullah et al. 2011). Ebenstein thought that China's rapid industrialization seriously degrades the water quality of rivers and lakes, and estimated the changes in water pollution of related river basins (Ebenstein 2012). With respect to water pollution control measures, economic governance is advocated in foreign countries because of their high market economic development. Some research studies have proved the importance of legal measures on water pollution control. McClelland posited that the pollution reduction cost of the paper-making industry under the regulation of the Clean Water Act includes considerable energy, material and labour costs, and proposed countermeasures to water pollution (McClelland et al. 1999). Dasgupta suggested utilizing the transaction nonpoint water pollution license of the pollution offset system as a nonpoint water pollution control measure to reduce transaction cost through a centralized management market (Dasgupta et al. 2001). In China, Wang evaluated pollution charges by metering and found that charges influenced the expenditures of enterprises for the terminal wastewater disposal (Wang 2002). In Spain, Martínez assessed different policies on agricultural nonpoint pollution control and discovered that taxing nitrogen fertilizer reduces pollution and costs more effectively than increasing water price (Martínez et al. 2004). Malik investigated the feasibility of private wastewater treatment plants under India's deposit refund system and discussed the incentive method for private investment in water pollution control (Malik et al. 2005). In India, Birol utilized the stated preference environmental value assessment technique to evaluate the performances of residents along riverbanks in

improving wastewater treatment of wastewater treatment plants. He suggested that the government should increase its investments to enhance the pollution reduction capabilities and technologies of wastewater treatment plants (Birol et al. 2010). Dai discussed the regulatory strategies of China and the European Union on establishing water quality objectives and designing and implementing water pollution control strategies. The study emphasized agricultural water pollution control measures (Dai 2015). Nilsson discussed the effects of laws on biological eutrophication control on Baltic seawater pollution (Nilsson et al. 2015). The related literature illustrates that foreign scholars are highly concerned about water pollution in river basins and have extensive experience in river basin pollution control. Therefore, these scholars have conducted numerous in-depth studies focusing on control measures from an economic perspective. However, there are few research studies on the water pollution status and regulatory measures of a single basin. Some Chinese studies on water pollution control measures for the Xiang River only discuss a single aspect. Therefore, this paper analyses current status of water pollution in the Xiang River basin to provide corresponding regulatory references for water environment rehabilitation and to effectively inhibit the water degradation in the Xiang River.

## CAUSES OF WATER POLLUTION IN THE XIANG RIVER BASIN

**Large-scale emission of industrial wastewater:** Under normal conditions, the most serious water pollutant source is industrial wastewater, which has a complex composition and many fatal toxins with strong destructive power to biology. Although some metallic elements are essential to human bodies, others, such as Hg, are not. Given that benthonic organisms in rivers are the final home of metal particles in water, they are the most directly influenced by sedimentary metals.

**Extensive pesticide use:** Pesticides are highly persistent in soils and will slowly migrate through soils to the aqueous layer. Underwater pesticide pollution does not become obvious until years after the first pesticide application. Some negative effects appear years after stopping pesticide use. In most cases, pesticides indirectly influence the water body, hindering underwater recovery through the enrichment effect in the biologic chain. Therefore, water pollution caused by pesticides can affect public health very seriously.

**Urban sewage pollution:** With urban population growth and improved living standards, the discharge quantity and load of urban sewage tend to increase sharply and change quickly. The domestic sewage from large cities and megalopolis surrounding the Xiang River basin has been

increasing annually. Given the poor collection and treatment facilities of urban sewage, the actual processing ratio and level of domestic sewage are extremely low, whereas the disordered discharge of domestic sewage and pollution share ratio increase quickly, resulting in serious urban water pollution and intensifying river and lake pollution in the basin.

**Ineffective government control measures:** Existing water pollution control in the Xiang River basin has not fundamentally improved, although water pollution continues to intensify. Information on the severity of water pollution control is lacking. Technological hardware construction, such as water environment monitoring, has been developed to some extent in the basin. However, the government does not provide adequate attention to related laws, policy formulation, and institutional arrangement. Understanding of the characteristics and laws governing water pollution is also lacking. Therefore, the government is incapable of overall planning and establishing comprehensive control measures from the basin and system perspective.

### CURRENT STATUS OF WATER POLLUTION IN THE XIANG RIVER BASIN

Rapid industrial development and scientific and technological progress in urban agglomeration in the Xiang River basin result not only in economic prosperity, but also in ecological and environmental damages. Additionally, the historical industrial layout of the basin is unreasonable, further causing serious environmental problems in addition to water pollution, such as atmospheric pollution, and degradation of ecological and environmental functions.

**Poor water quality and complicated water pollution:** In 2015, the statistical bulletin of water environment in Hunan province designated the Xiang River basin with the poorest water quality. The water qualities of 40 provincial monitoring sections are not optimal (Fig. 1). Water quality in most upstream sections, including Yongzhou, Hengyang, and Zhuzhou, is relatively good, whereas water quality in Changsha, Zhuzhou, and Xiangtan is relatively poor. On one hand, eight urban industries stand on both banks of the Xiang River. All are heavy industries, which can intensify industrial pollution. Moreover, the large-scale development of the livestock and poultry industry leads to the superposition of industrial, domestic, and historical pollution of the Xian River basin, further complicating local water pollution and exhibiting new developmental trends. The basin runs through eight cities in Hunan Province, covering the most economically developed regions. Most enterprises are located on the basin's banks, and the Xiang River is the most important water source in Hunan Province. Water pol-

lution in the basin significantly affects industrial, agricultural, and fishery productions. Water from the Xiang River has become too hard because of poor water quality and high heavy metal content. Water hardness not only makes treatment difficult and increases production costs, but also blocks and corrodes production equipment and influences product quality. At the same time, water pollution threatens fishery resources and affects the physical health and life security of human beings in the long run.

**Increased exhaust emission and atmospheric pollution intensify water pollution:** The continuous optimization and upgrading of the industrial structure decrease the proportion of primary industries and decrease the proportion of secondary industries, as well as intensify atmospheric pollution along the Xiang River basin (Fig. 2). Industrial exhaust emissions from the urban agglomeration in the basin may still increase (Fig. 3) and are higher than the average provincial level. In recent years, industrial dust discharge has decreased to some extent, and the discharge per capita is slowly approaching or even becoming lower than the average provincial level. However, the decrease in industrial emissions is not obvious. Industrial emissions are still a serious threat to improving the environmental quality of cities in the basin. Industrial emissions are also the main cause of acid rain and other hazards. Acid rain not only significantly accelerates the corrosion of buildings, metals, textiles, cultural relics, and historical sites, but also poses serious threats to soils, animals, and plants in vulnerable regions. Atmospheric pollution causes optical haze pollution, social economic losses, and casualties in urban agglomeration in the basin. In recent years, organic pollution in the basin has increased continuously. Although some sewage treatment plants have been constructed in several prefecture-level cities along the Xiang river, most urban domestic sewage is directly discharged into the river, intensifying water quality degradation and introducing excessive amounts of organic pollutants (e.g., nitrogen and phosphorus) to different drinking water source sections. Agricultural wastewater in the Xiang River basin results from extensive fertilizer and pesticide use. Every year, rainwater causes pesticides and fertilizers to converge into runoff for discharge into the Xiang River, drastically increasing organic pollutants in the river. Meanwhile, as the cultivation industry continuously develops, the direct discharge of coastal animal excrement intensifies the pollution in the Xiang River.

**Biodiversity reduction and water pollution seriously degrade ecological and environmental functions:** The Xiang River basin, which belongs to a subtropical evergreen broad-leaved forest, has adequate rainfall and sunlight, diverse

landform types, a good environment for animal and plant growth, a variety of animals and plants, as well as a high number of rare species. However, the economic development, accelerating industrialization, and exploitation of the basin decrease its biological diversity and the ornamental value of its ecological landscapes. Changes in the ecological environment and surface vegetation in the basin modify precipitation in the area. For several successive years, the autumn and winter precipitation in the basin has been inadequate. Additionally, the water level in the Changsha Section has been lower than the standard level for eight successive years, exposing a large area of the riverbed.

**Mass exploitation of mineral resources causes serious water pollution:** The Xiang River basin possesses abundant mineral resources. More than 300 minerals have been discovered in the basin, and its tungsten reserves rank first in China. In the urban agglomeration in the Xiang River basin, the main industries are nonferrous metal mining and dressing, coal mining and processing, ferrous metal mining and dressing, non-metallic mining and dressing, and non-metallic mineral production. These metal industries and their effluents influence water quality in basin. Meanwhile, scum from iron manufacturing, coal gangues from coal mining, and tail sands and waste stones from nonferrous metal mining and dressing occupy a vast area of the basin, seriously polluting water in the Xiang River and affecting the riverbed. Cities in the basin have been affected by the long-term accumulation of “three-waste” pollutions and are surrounded by the potential risks of heavy metal, radioactive, and arsenic pollutions. Although heavy metal emissions in industrial wastewater have decreased continuously over the past years, they can still accumulate and greatly threaten the security of drinking water, surface water, and underground water. Furthermore, the long-term, excessive content of heavy metals influences crop quality and is disadvantageous to the living quality of humans and production safety (Fig. 4).

## LAWS AND REGULATION FOR WATER POLLUTION CONTROL IN THE XIANG RIVER

**Perfecting the legal construction for scientific decision-making regarding pollution control in the Xiang River basin:** Faulty administrative decisions by the government are the main reason for the failure in basin pollution control. Negative actions, intervention in law enforcement, and faulty governmental decisions in environmental protection are the root causes of the protracted treatment of environmental problems. Therefore, the government shall perfect the scientific and democratic decision-making mechanism, determine administrative decision-making authority according to laws, follow the administrative decision-making pro-

cedure, and perfect the decision-tracking feedback and responsibility system. In addition, follow-up actions shall be taken. Supporting laws and regulation for the overall planning of the relationship between pollution control and administrative decision-making shall be established and perfected. A uniform, administrative management and decision-planning strategy shall be enlisted for managing the wetland, intertidal, dam, forest, and fishery zones along the basin. Administrative decision-making and law enforcement, judicial constraint criteria, and a framework for pollution control shall also be constructed. Other concerns include: perfecting the formulation system of corresponding administrative decisions, enacting the “Formulation of Key Administrative Decisions for Xiang River Basin Management”, determining the scope of corresponding events, and establishing a comprehensive standard system integrating decision-planning, investigation, consultation, demonstration, legal examination, group discussion, and announcement of results. The public shall be consulted in advance on key administrative decisions regarding pollution control through publicity, audit, and information sharing per legal requirements. The accepted public opinions and reasons must be disclosed as well. The explanation and disclosure system for reasons (legality reasons and legitimacy reasons) of key decisions should be seamless. A risk evaluation committee composed of social professional personnel, government legal advisers, and government staff shall be established to control decisions regarding the Xiang River pollution. The committee shall perform pre-examination, evaluate the legal risks and implementation of key decisions, propose opinions and suggestions, and develop a complete and advanced middle examination and evaluation mechanism for key administrative decisions.

**Perfecting the legal construction for the Xiang River basin administration:** Pollution control in the Xiang River basin requires uniform management organization. When establishing the water pollution control system, the management must implement unified command, reinforce regulation, promote departmentalization of main management functions, and determine a single power structure and administrative leadership system. Although the new “Water Pollution Control Act” realizes the importance of a unified management organization and explicitly stipulates the combined basin-district management system for water resources, it does not highlight the juridical status of basin management organization in administration and views the basin management organization and district-based management organization to have equal juridical status. Therefore, the government shall construct an institutional, multi-layer environmental cooperative system under the leadership of the Hunan Provincial government and with the participa-

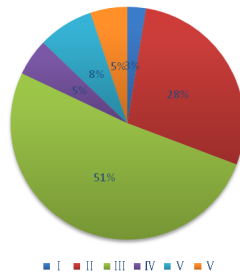


Fig. 1: Water quality at 40 monitoring points in the Xiang River basin (Data from the Statistical Bulletin of Water Environment in Hunan Province in 2015).

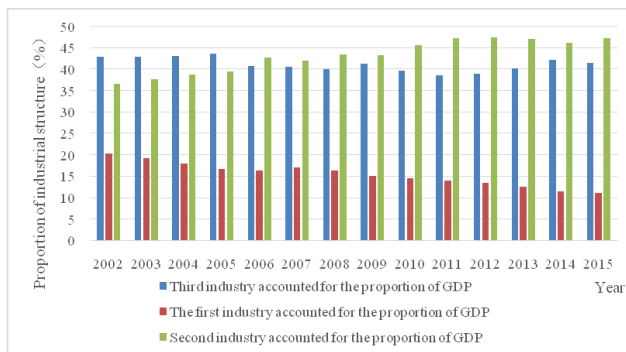


Fig. 2: Industrial structure of urban agglomeration in the Xiang River basin (Data are from "Statistical Yearbook of Hunan Province" 2015).

tion of municipal government agencies in the basin. The functions, status, power range, duties, organization principle, financial management, and relationship of the cooperative system with the local governments shall be determined per laws and regulations. The Xiang River basin management committee shall be established. The corresponding legislative authorities shall be endowed with responsibilities, such as the right to issue regulations for local basin water resources and formulate special, management regulations based on local situations or operable management rules according to national laws and regulations. Local regulations shall stipulate the juridical status, terms of reference, and size of personnel force of the Xiang River basin management committee, who shall build a good legal foundation for pollution control in the basin. To change the single vertical management mode and develop a multi-level and multi-subject pollution control network that combines regional collaborative management and vertical management, the Xiang River basin management committee can setup pollution control management organizations in different districts and cooperate with the local governments' environmental protection department. This management committee is conducive for the scientific, comprehensive, legal, and reasonable planning and management of all affairs concerning the basin.

### Perfecting the legal construction for public participation in water pollution control in the Xiang River:

A joint conference system for the Xiang River pollution control shall be established to provide an innovative and feasible choice for public participation in pollution control, which refers to the successful international application of public participation system in basin management. Moreover, the system shall appoint self-nominated and voted government officials and officials of environmental protection agencies of cities and counties, non-governmental organizations, enterprise groups in administrative districts, as well as industries in a region with certain population. These appointments will act as the public's representatives, providing full play to democracy and opinions for pollution control planning. The officials will solve key engineering problems and investment issues through meetings held by one or several parties, supervise the execution of related control planning, and coordinate pollution disputes. The environmental information disclosure of the system shall also be perfected. The disclosure system will include the appointment of a special department of the environmental protection administration to oversee the daily work concerning environmental information disclosure and the establishment of a public expression system. The disclosure system shall protect the public's right to know about water environmental situations in the Xiang River basin, update the public, improve awareness of participation in pollution control, enhance responsibility and sense of mission in corresponding decision-making, and motivate the public's initiatives and creativity in pollution control. Moreover, the special department is expected to initiate and promote environmental information disclosure regarding the Xiang River basin, to accomplish information disclosure rules of the government, to establish an environmental information system, and to improve the public's access to services. Range, method, time limit, and contents of information disclosure shall be determined. Except for classified content, all important policy information involving public concerns shall be disclosed in an accurate and timely manner. Government information disclosure about financial budget, public resource allocation, key construction engineering project approval, and implementation related to pollution control in Xiang River basin shall be promoted to realize completely open expenditures and engineering projects. Key attention shall be paid to establishing a social evaluation system for Xiang River environmental information disclosure and creating and perfecting related internal assessment, annual report, and responsibility systems.

### CONCLUSIONS

The Xiang River is the main drinking water source for resi-

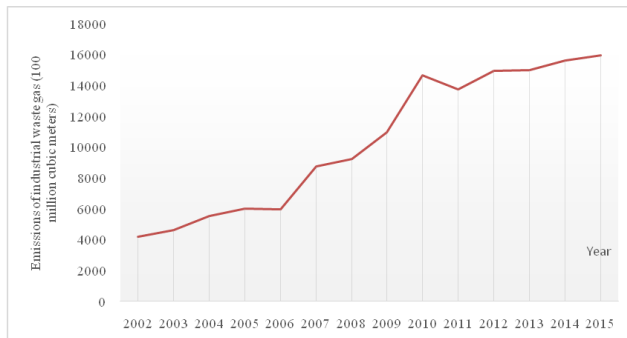


Fig. 3. Industrial exhaust emissions in the urban agglomeration in the Xiang River basin (Data are from Environmental Statistical Yearbook of Hunan Province 2015).

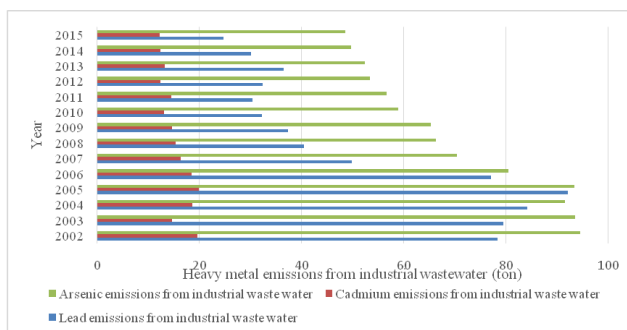


Fig. 4. Heavy metal emissions in industrial wastewater from the urban agglomeration in the Xiang River basin (Data from "Environmental Statistical Yearbook of Hunan Province" 2015).

dents in the Xiang River basin, the carrier of water pollutants from urban domestic activities, agricultural emission, and industrial production along the river, and the main water supply for regional economic development. To analyse current status and regulatory measures of water pollution in the Xiang River basin of China, appropriate control measures are explored. Based on the 2002-2015 statistical data of urban agglomeration and environmental pollution in the Xiang River basin, the causes, current status, and changes of water pollution in the basin are analysed. Results demonstrate that the Xiang River basin is moderately polluted; most of its water bodies have III-level pollution. Approximately 70% of the water pollution is contributed by III-level, IV-level, V-level, and inferior V-level pollution. Water pollution of the Xian River basin is mainly caused by large-scale industrial wastewater drainage, extensive pesticide use, urban sewage, and ineffective government control measures. The water pollution in the basin has the following characteristics: 1) water pollution is increasingly complicated; 2) industrial waste gas and atmospheric pollution intensify water pollution; 3) degraded ecological environment functions cause abnormal self-recovery of the water body; 4) large-scale exploitation of mineral resources in-

tensifies water pollution. Water pollution in the Xiang River basin can be effectively improved by perfecting legal constructs of scientific decision, administrative organization, and public participation, thus realizing sustainable utilization and optimized allocation of water resources. Given that, this paper focuses on the overall status and regulatory measures of water pollution in the Xiang River basin from 2002 to 2015. We recommend a further research on following topics: trans-regional water pollution, essential relationship between water pollution and urban economic development, innovative water pollution control mechanisms, water pollution control based on ecological compensation, specific laws and regulations on trans-regional management, and administration legalization in the Xiang River basin.

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