

Water Contamination in Industrial Zones and Public Health Implications

Environmental Health Sciences

Authors: Caile Lee, Xarina Y. Zaqtan, Hanseo Zhao, Roy Kim

Editor: Roy Kim

1. Introduction

The Greater Bay Area (GBA) has one of the most complex and special river networks across the globe due to its composition and structure, tributaries and outlets. The humid subtropical climate has led to high and uneven annual precipitation. Under rapid urbanisation and economic growth, the severity of water contamination in GBA has gradually increased over time by active industrial and agricultural activities. The root causes of water contamination in the GBA stems from 3 interconnected factors. First, untreated domestic and industrial sewage, particularly electronics, textiles, and manufacturing, releases heavy metals and organic pollutants into waterways. Second, rapid urbanization has outpaced the wastewater treatment infrastructure, leaving many areas to rely on inadequate systems that fail to filter waste. Third, agricultural runoff containing fertilizer and pesticides contribute towards nutrient pollution and eutrophication. Combined, these factors create a cycle where economic benefit growth fuels contamination, threatening the very resource that sustains growth (*Geography Learning and Teaching Resources on Guangdong-Hong Kong-Macao Greater Bay Area*).

1.1 Definitions

Water Contamination: Introduction of chemical, physical or biological agents into natural bodies of water, degrading water quality and rendering it toxic/harmful towards organisms relying on that water.

Industrial Zones: Designated areas that are zoned, planned and regulated for concentration of industrial activities such as textile and dyeing; oil and gas drilling; and chemical manufacturing.

2. Impacts on Regional Community

According to the Geography Learning and Teaching Resources (2022), the impacts on local communities are severe. Residents in downstream areas are more prone to consume or use polluted water. This may result in health complications, including skin infections, gastrointestinal diseases, and exposure to carcinogens that cause cancer. On top of health issues, the local economy is at risk as well. Fishermen and farmers see their livelihood collapse as fish stocks die and crops fail. Tourism and real-estate value decline around heavily-polluted areas. Furthermore, marginalized communities bear the heaviest burden as filtering systems fail and financial budgeting becomes tight — fail to afford reallocation or bottled water — they resort to drinking contaminated water to survive. This psychological toll is significant, neglecting will only create chronic stress and erode trust in government institutions.

3. Broader Implication

The issue extends beyond the GBA. China is one of the most economically dynamic regions and recent development of GBA has promoted it to a role model. If water contamination remains unaddressed, it would signal that rapid economic growth and environmental health are fundamentally incompatible. This will model other countries to follow this exploitative trend for economic gains, undermining sustainability goals. Furthermore, contaminated water does not respect administrative boundaries. Pollutions in the Pearl River Delta can potentially affect fisheries and biodiversity across the South China Sea. Finally, health costs and productivity losses from waterborne diseases in prosperous regions are the hidden economic burden that hits the hardest. Addressing water contamination issues is not merely an environmental issue, it is a prerequisite for long-term economic stability, public health and regional cooperation.

4. Policy Evaluation

Current public health policies have been set in place within GBA to better oppose the health issues which water contamination causes. Two of these policies include the Regulations on the Collaborative Protection of the Maozhou River Basin between Shenzhen and Dongguan, along with the Local Legislation on Scattered Industrial Waste Water within pearl river delta cities.

4.1 The Regulations on the Collaborative Protection of the Maozhou River

These regulations have been set into place within Shenzhen and Dongguan to better improve the water quality of the Maozhou River as it has been heavily polluted in previous years. They spread awareness of the risks of contaminated water along with a legally binding need for statistics across the cities on the progress of improving the river's water. This is a beneficial regulation as it involves multiple cities following a similar set of rules. This allows a collective goal towards tackling water contamination and improving the ecology of the river which cities involved all adhere to. The regulations were put in place based on previous successful measures, providing an already working and stable foundation (Jiang et al.). This overall makes the regulations on the collaborative protection of the Maozhou river actively working successfully.

While there are many strengths to the idea of these regulations, they have limitations to their function as well. For one, because they are inter-city regulations, many of the rules may spike controversy across cities causing conflict between governments. This is an issue as it would slow down the action planned through the regulations. It is also only a successfully working regulation plan if both cities continue to work to maintain its policies. Additionally, the cost for the technology, administration, and enforcement in a largely industrialized region makes it difficult to ensure that the regulations can be carried out successfully.

4.2 The Local Legislation on Scattered Industrial Waste Water

This legislation focuses more on scattered waste water in smaller volumes that are not being disposed of or decontaminated actively. It aims to create a storage space that smaller enterprises along the pearl river can collectively use to treat the water contamination from smaller portions of waste (Safa Baccour et al.). This is beneficial as it targets many minor water contamination issues that have accumulated, creating one greater solution for the scattered waste water. It is cost efficient and designed to work within other pieces of technology allowing it to be used easily in a variety of locations and systems.

Although this model has benefits in cost and function, it also includes weaknesses in sustainability and enforcement. As it is made for smaller enterprises, it is difficult for government officials to keep track and ensure that each organization is correctly enforcing the model into their system. The fees it takes towards transport and treatment are then economically

unsustainable as it can not be confirmed that all organizations will comply with the requirements of the model as a part of their greater system.

5. Policy Recommendations

An effective approach to mitigate water contamination in industrial zones in GBA is through the implementation of real-time, integrated water quality monitoring systems. Particularly for heavily industrialized areas, a long-term, adaptive management framework would address detection gaps and ensure sustained improvements in public health.

The importance of long-term planning is informed by international case studies such as the New York Hudson Bay and the London River Thames purification project. Both waterways were once heavily contaminated by industrial discharge and urban waste. In order to address this issue, the New York Hudson Bay began with the initiation of Maintenance and Monitoring Program (OM&M), water column monitoring, sediment monitoring, fish monitoring, habitat monitoring, and cap monitoring (EPA). With wide-scale monitoring, active clean up and treatment and contamination source identification and enforcement were available to mitigate water pollution. Similarly, the London River Thames recently demonstrated a remarkable recovery from severe contamination. Conservationist Alison Debney highlighted this recovery by saying “the Thames may have been declared biologically dead in the 1950s, but the estuary we see today demonstrates just how quickly things can change when decisive action is taken” (Elgueta). The process toward recovery involved constant monitoring on the biodiversity of riverbanks. To counter its loss, new aquatic habitats have been created across areas that have been industrially contaminated, performing a multi-layered restoration strategy (Bodnar). These two cases provide valuable insights for the GBA that real-time monitoring systems should be deployed across major industrial zones.

Recent advancements in environmental monitoring emphasize the importance of integrating digital technologies into water management systems. Water quality in coastal and marine systems is closely linked to eutrophication processes and phytoplankton dynamics, and modern monitoring methods are essential for understanding and managing these changes (Pavlidou). Cyber-physical systems and Internet of Things (IoT) technologies enable the integration of physical infrastructure with real-time data collection and computational analysis, improving

system scalability, reliability, and responsiveness in critical sectors such as environmental management and smart infrastructure systems (Griffor). It is important to note that the GBA is a large integrated economic and urban region that includes major cities such as Guangzhou, Shenzhen, Hong Kong, and Macau designed as a highly connected innovation and manufacturing hub. Thus these examples of water monitoring techniques are especially pertinent in the context of water contamination because it enables ongoing monitoring of water quality and promotes early pollution event detection, Eutrophication processes, which are frequently connected to industrial and urban pollution. It can also be better understood and managed by continuously monitoring indicators like nutrients levels, dissolved oxygen, and biological activity (e.g., phytoplankton changes) (Griffor). Overall, these methods lend credence that contamination requires continuous, data driven monitoring of biological and chemical indicators.

6. Conclusion

Driven by rapid urbanization, the GBA has experienced continuous problems with water contamination under weak waste management, unregulated industrial disposal, and excessive agricultural runoff. Existing policies have been researched, including Maozhou River collaborative regulations and scattered industrial wastewater legislation. Nevertheless, limitations hinder accurate monitoring due to small-scale industries. To ameliorate this limitation, research on international examples have been taken, where policies have been found in Hudson River and the River Thames utilizing the integration of real-time monitoring with advanced systems such as IoT. This novel technology improves monitoring scalability and reliability, reinforcing regulatory strength and potentially benefiting existing policy implementation. Above all, the integration of cost-effective monitoring technologies can contribute to addressing the water contamination in the GBA and reduce related health complications.

Bibliography

- Baccour, Safa, et al. "Water Quality Management Could Halve Future Water Scarcity Cost-Effectively in the Pearl River Basin." *Nature Communications*, vol. 15, no. 1, 6 July 2024, www.nature.com/articles/s41467-024-49929-z, <https://doi.org/10.1038/s41467-024-49929-z>.
- Bodnar, W. (2025, December 12). Analysis: How riverside habitats are being restored along the Thames. UCL News. <https://www.ucl.ac.uk/news/2025/dec/analysis-how-riverside-habitats-are-being-restored-along-thames>
- Cundy, A.B., et al. "A Systematic Review of Emerging Contaminants in the Greater Bay Area (GBA), China: Current Baselines, Knowledge Gaps, and Research and Management Priorities." *Environmental Science & Policy*, vol. 131, May 2022, pp. 196–208, 10.1016/j.envsci.2022.02.002.
- Elgueta, A. (2026, January 19). River Thames cleaner but at risk from climate change, report says. BBC News. <https://www.bbc.com/news/articles/cy8pv7p5djo#>
- Environmental Protection Agency. (n.d.). EPA. <https://www.epa.gov/udsonriverpcbs/udson-river-cleanup>
- Geography Learning and Teaching Resources on Guangdong-Hong Kong-Macao Greater Bay Area (Greater Bay Area) Water Resources in the Greater Bay Area Guangdong-Hong Kong-Macao Greater Bay Area. 2022.
- Griffor, E., Roth, T., Dunaway, W., Guo, W., & Song, E. (2025, March 26). Cyber Physical Systems and internet of things program. NIST. <https://www.nist.gov/programs-projects/cyber-physical-systems-and-internet-things-program>
- Jiang, Jiping, et al. "An Integrated Supervision Framework to Safeguard the Urban River Water Quality Supported by ICT and Models." *Journal of Environmental Management*, vol. 331, 1 Apr. 2023, pp. 117245–117245, <https://doi.org/10.1016/j.jenvman.2023.117245>.

Pavlidou, A., Hoteit, I., Martins, A., & Varkitzi, I. (2026, March 6). Recent advances in water quality monitoring. MDPI.

<https://www.mdpi.com/2072-4292/18/5/820#:~:text=Recent%20advancements%20in%20both%20coastal,%2C%20eutrophication%2C%20and%20phytoplankton%20diversity.>

“Thirsty And Underwater: Rising Risks In Greater Bay Area - CWR.” CWR, 12 Feb. 2025,

<https://cwrrr.org/resources/analysis-reviews/thirsty-and-underwater-rising-risks-in-greater-bay-area/>. Accessed 22 Apr. 2026.

Wang. “Ecological Risk Assessment of 50 Emerging Contaminants in Surface Water of the Greater Bay Area, China.” *The Science of the Total Environment*, vol. 907, 2024,

<https://pubmed.ncbi.nlm.nih.gov/37884156/>, 10.1016/j.scitotenv.2023.168105. Accessed 22 Apr. 2026.