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# Spatiotemporal distribution of ecological risk of antibiotics in seven major river basins of China: An optimized multilevel assessment approach

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**Abstract:** Antibiotics have been recognized as emerging pollutants due to their ecological and human health risks. This paper aims to enhance the ecological risk assessment (ERA) framework for antibiotics, to illustrate the distribution of these risks across different locations and seasons, and to identify the antibiotics that pose high ecological risk. This paper focuses on 52 antibiotics in seven major basins of China. Relying on the optimized approach of ERA and antibiotic monitoring data published from 2017 to 2021, the results of ERA are presented in multilevel. Across the study area, there are marked variations in the spatial distribution of antibiotics' ecological risks. The Huaihe River Basin, the Haihe River Basin, and the Liaohe River Basin are the top three in the ranking of present ecological risks. The research results also reveal significant differences in temporal variation, underscoring the need for increased attention during certain seasons. Ten antibiotics with high contribution rates to ecological risk are identified, which is an important reference to formulate an antibiotic control list. The multilevel results provided both risk values and their ubiquities across a broad study region, which is a powerful support for developing ecological risk management of antibiotics.
**Keywords**: antibiotics; ecological risk assessment; river basins; spatiotemporal distribution

## 1. Introduction

Antibiotics, due to their ecological toxicity and the potential to promote antibiotic resistance, have been widely recognized as emerging environmental pollutants. In China, 70%–90% of antibiotics are excreted in their active form or as metabolites. Given the insufficient removal efficiency of existing wastewater treatment technologies, these substances persist in aquatic ecosystems, posing long-term ecological threats (Li et al., 2020; Liu et al., 2018; Zhang et al., 2021). As one of the world's largest producers and consumers of antibiotics, China has experienced considerable challenges with antibiotic overuse. In response, the State Council of China issued the "Action Plan for the Control of New Pollutants" in 2022, classifying antibiotics as priority emerging pollutants and mandating nationwide investigations, environmental monitoring, and risk assessment to inform regulatory frameworks. Currently, most previous studies focus on a limited number of antibiotics and localized water bodies, providing insufficient evidence for national-level prioritization.

## 2. Key Findings and Results

This study analyzed the spatiotemporal ecological risks of 52 antibiotics across seven major river basins in China (Heilongjiang, Liaohe, Haihe, Yellow, Huaihe, Yangtze, and Pearl Rivers) from 2017 to 2021, using an optimized multilevel ERA framework. Major findings include:

- Spatial Distribution: the Fig. 1 shows the distribution of monitoring sites and locations of megacities. The Huaihe, Haihe, and Liaohe River Basins were identified as the regions with the highest antibiotic ecological risk, based on combined RQ values and risk ubiquity indices. These basins exhibited medium to high levels of antibiotic pollution, likely due to high population density, intensive agriculture, and wastewater discharge.

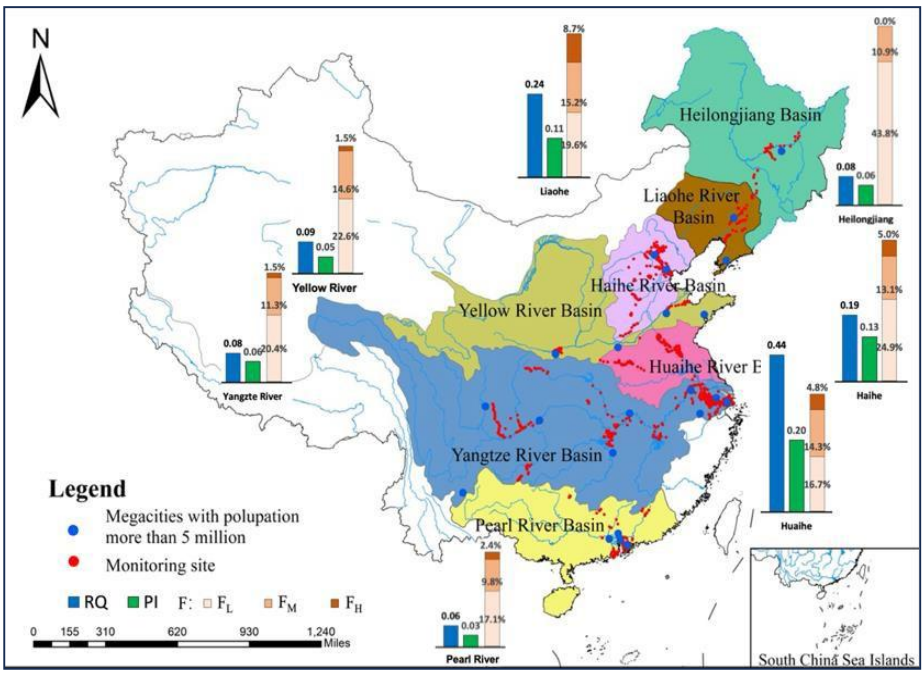



**Figure 1** Results of Multilevel Ecological Risk Assessment of Seven Major Basins in China,and Monitoring Sites Distribution

- Temporal Variation: the temporal variation of average ecological risk values in seven major river basins during thedry and wet periods of the year is presented in Fig. 2. The study revealed significant seasonal differences in ecological risks. In most basins (e.g., Liaohe, Haihe, and Heilongjiang), risk levels were substantially higher during the dry season compared to the wet season. These variations are attributed to lower water flow, higher per capita antibiotic usage during flu season, and reduced degradation due to lower solar radiation and biological activity in winter. Notably, the Huaihe Basin showed an inverse pattern, likely linked to regional aquaculture practices.

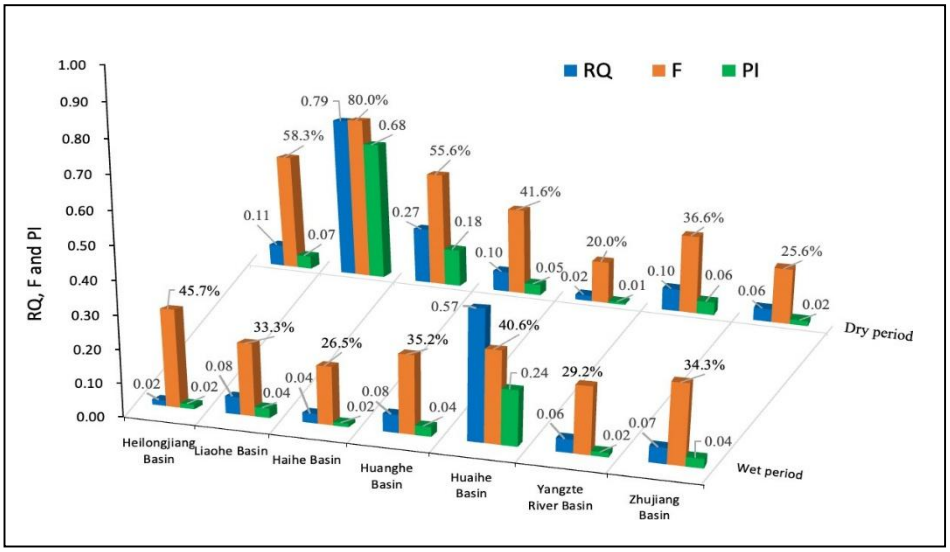
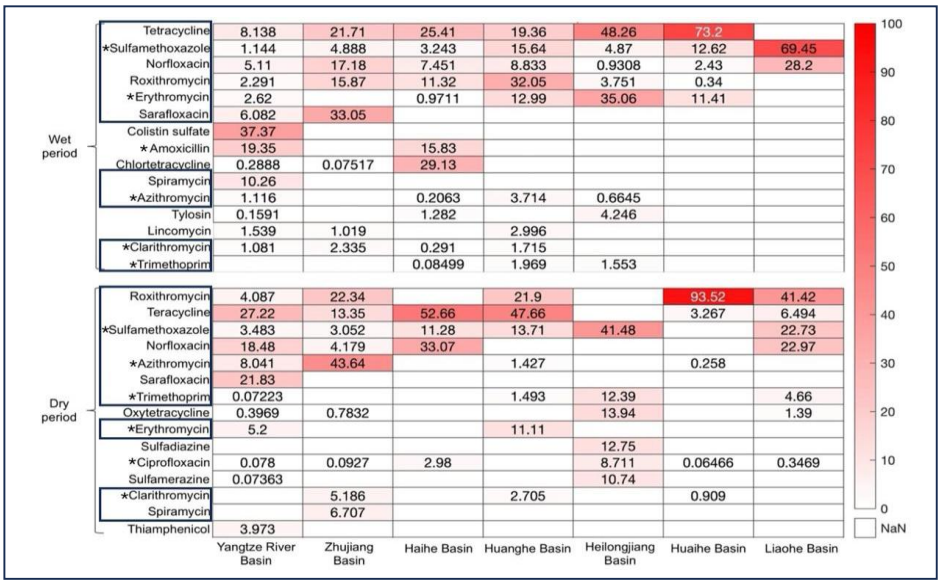



**Figure 2** Temporal Distribution of Multilevel Ecological Risk Assessment in Seven MajorRiver Basins

- Priority Antibiotics: ten antibiotics were consistently identified as major contributors to ecological risk across basins and seasons. These included compounds such as tetracycline and roxithromycin, known for their low removal efficiency in wastewater treatment processes and high environmental persistence. Seven of these are also listed on the European Union's watch list, reinforcing their significance for targeted control.




*Note: the antibiotics marked by "*" have been listed in the watch list of substances by the European Union*

**Figure 4** Thermodynamic Chart of the Contribution Rate of Antibiotics to Priority Index in Seven MajorRiver Basins (Unit: *%*)

## 3. Conclusion and Suggestions

The results provide valuable insights for national-scale antibiotic pollution control in China. The identification of high-risk basins and priority antibiotics can guide the development of region-specific monitoring programs, optimize wastewater treatment strategies, and support the creation of an official control list for high-risk antibiotics. Additionally, the clear evidence of seasonal variation underscores the need for time-sensitive risk management measures, especially during high-risk periods such as the dry season or periods of peak antibiotic use.

In summary, this research contributes robust scientific support for environmental policy-making on antibiotic pollution in aquatic ecosystems, offering both a strategic framework and actionable priorities for improved ecological risk governance in China.

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