

Regional Adaptation of Water Quality Criteria for Protection of Human Health: A Case Study of Baiyangdian Lake

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Abstract Water quality criteria are the core thresholds for ensuring the safety of water environment and human health, but China's research on water quality criteria for human health started relatively late, and it is difficult to meet the needs of regional differentiated control. As the largest shallow grass lake in the North China Plain, Baiyangdian Lake's water environment quality is directly related to regional ecological stability and the health of surrounding residents. In this paper, combining the regional pollution characteristics and criteria research needs of Baiyangdian Lake, the problems faced by current research on human health water quality criteria were analyzed. The most appropriate method for obtaining technical parameters was adopted, and parameter localization was conducted, providing reference for the prevention and control of human health risks in Baiyangdian Lake and the formulation of criteria in other watersheds.

Key words Human health water quality criteria; Baiyangdian Lake; Regional characteristics; Parameter localization

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Water quality criteria refer to the maximum concentration threshold of pollutants in water bodies that do not have harmful effects on the ecological environment and human health. They are mainly divided into water quality criteria developed to protect aquatic organisms and water quality criteria developed to protect human health^[1-3]. Compared to developed countries such as Europe and America, China started relatively late in research on water quality criteria, and there is still a lack of research on water quality criteria for human health^[4]. In 2017, the Ministry of Ecology and Environment issued and implemented the *Technical Guidelines for Deriving Water Quality Criteria for the Protection of Human Health* (HJ 837-2017) (referred to as the *Guidelines*), providing a basis for the standardized development of human health water quality criteria research nationwide^[5].

China has a vast territory, with significant differences in environmental characteristics among different regions. There are significant differences in residents' lifestyles, dietary structures, and intake of aquatic products. Different regions require different water quality criteria and management standards. Therefore, research on water quality criteria that adapt to local characteristics has become a key direction for the development of environmental science. At present, relevant research mainly draws on mature water quality criteria derivation models from abroad, and combines with the characteristics of China's biota and regional differences, to establish regionally applicable water quality criteria derivation methods, providing scientific basis for the formulation of national water

quality criteria.

Under the guidance of the *Guidelines*, research on the human health water quality criteria in Baiyangdian Lake was conducted, and the localization and adaptation path of national technical guidelines in the region was explored. This paper could provide theoretical support and reference for the scientific formulation of regional water quality criteria.

1 Environmental characteristics and criteria research requirements in Baiyangdian Lake

Baiyangdian Lake is located in the north of North China Plain, with complex terrain. The overall terrain naturally forms three geomorphic types of mountains, plains and depressions from west to east. The total area of Baiyangdian Lake is about 366 km², and it consists of 143 sub-lake units and more than 3 700 trenches, with water and land alternating and rivers and lakes connected, forming a unique terrain feature of half water and half drought. The average annual precipitation in Baiyangdian Lake is about 500 mm^[6], and the distribution of precipitation is uneven throughout the year, with over 60% concentrated from June to September. Seasonal drought and ecological replenishment coexist, directly affecting the dilution and diffusion capacity of the water body and the risk of pollutant enrichment.

As the largest shallow grass lake in North China Plain, Baiyangdian Lake is an important core component of regional ecological security pattern, and its water environment quality is directly related to the stability of regional ecological functions and the health of surrounding residents^[7]. There are a total of 99 villages in Baiyangdian Lake, including 39 inner-lake villages and 60 lakeshore villages, with a permanent population of 217 000. Local residents have lived by the water for generations and rely on the

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lake for their livelihoods. Aquatic plants are widely distributed in the lake, and the aquatic resources are abundant, mainly including *Cyprinus carpio*, *Carassius auratus*, *Hypophthalmichthys molitrix*, *Pelteobagrus fulvidraco*, *Channa argus* and other fish, which are important sources of high-quality protein in the diet of residents^[8].

Baiyangdian Lake is located at the bottom of nine rivers, receiving upstream runoff while also carrying a large amount of sediment, nutrients, and pollutants into the lake area. Due to factors such as shallow water bodies, slow flow rates, thick sediments, and high organic matter content in the lake area, unique characteristics of pollutant occurrence and migration have been formed. The *Environmental Quality Standards for Surface Water* (GB 3838 – 2002) has been long adopted for water environment management in Baiyangdian Lake. In recent years, with the promotion of ecological water replenishment projects and the implementation of various environmental governance measures, the water quality has reached the Class III standard for perennial surface water, and conventional pollutants such as chemical oxygen demand and ammonia nitrogen have been effectively controlled. However, there is relatively little research on heavy metals, new pollutants, etc^[9].

At present, research on the water environment of Baiyangdian Lake mainly focuses on pollution characteristic investigation, spatiotemporal evaluation of water quality, and analysis of conventional pollution control effects. There is a lack of research on regional adaptation of human health water quality criteria, and a localized criteria system adapted to the structure of aquatic biological communities and residents' exposure characteristics in Baiyangdian Lake has not yet been formed. Therefore, it is urgent to carry out research on the human health water quality criteria of relevant pollutants in Baiyangdian Lake, in order to provide scientific basis and technical support for pollution risk control and residents' health protection in Baiyangdian Lake.

2 Problems faced in the research of human health water quality criteria

At present, China's water quality criteria research system has gradually established a theoretical framework and technical path with local characteristics. But there are still many shortcomings in water quality criteria research.

2.1 Lagging research on human health criteria Developed countries represented by the United States have formed a relatively complete water quality health criteria system^[10], while China's water environment criteria research still focuses on water quality criteria of protecting aquatic organisms. Research on human health water quality criteria is relatively weak, with insufficient depth and breadth. The current formulation and revision of the *Environmental Quality Standards for Surface Water* still lack technical support derived from human health water quality criteria.

2.2 Insufficient adaptation to regional differences China's water quality criteria have made great progress in recent years. However, there are significant differences in regional ecological

characteristics and population exposure parameters. It is difficult to adapt to regional differences and the protection needs of sensitive populations simply by adopting the national unified model or citing foreign criteria values. There are significant differences in water source types (surface water/groundwater), pollution sources, and water quality characteristics between the north and south of China, urban and rural areas, and different river basins. There are also significant differences in the drinking water patterns, dietary structures, and exposure levels of the population. For example, in some northern regions, the problem of excessive heavy metals in groundwater is prominent, while in some southern river basins, organic pollution is predominant. Compared with foreign countries, the drinking water intake of Chinese residents is about 15% – 20% higher than that of European and American populations, and the dietary structure difference rate exceeds 30%.

2.3 Incomplete basic data system Basic data are the core prerequisite for the derivation of human health water quality criteria, including pollutant toxicity data, population exposure parameters, bioaccumulation data, etc. There are still obvious shortcomings in the basic data mentioned above in China, and there is a serious lack of localized measured data, which greatly restricts the scientific and regional applicability of water quality criteria derivation.

3 Obtaining criteria parameters for human health water quality

Referring to the relevant requirements of the *Guidelines*, based on the pollution characteristics and population exposure characteristics of Baiyangdian Lake, the most appropriate on-site research and questionnaire survey methods in Baiyangdian Lake were selected. The key technical parameters such as exposure parameters and bioaccumulation factors were systematically sorted and optimized.

3.1 Exposure parameters Field survey is an important means of obtaining regional exposure parameters. As the core element of quantitative assessment of environmental health risks, exposure parameters directly determine the accuracy of measuring the dose of pollutants ingested by the human body and are key quantitative indicators that characterize the correlation between environmental media and human exposure. The acquisition of exposure parameters is prioritized through standard survey methods. In the absence of actual exposure parameters, national or local recommended values can be used. However, the exposure parameters recommended at the national level represent the national average level and are difficult to reflect the exposure characteristics of specific regions. Therefore, this paper focuses on the two main exposure pathways of drinking water and fish intake in Baiyangdian Lake. Through a questionnaire survey, important parameters such as body weight (BW), drinking water intake (DI), and fish intake (FI) are obtained. The survey covered 10 inner-lake villages in 3 counties and 5 townships, and there are 500 samples.

3.1.1 BW. The survey results show that BW of residents in inner-lake villages of Baiyangdian Lake is 66.4 kg, which is higher than the recommended value of 60.6 kg in the *Guidelines*. Compared with the results of the special investigation by the Ministry of Environment of China^[11], from a regional analysis, the average adult body weight in rural areas of Hebei Province is 64.7 kg, which is higher than the national level of 59.7 kg. The urban-rural difference is shown as urban > urban-rural > rural, as shown in Table 1. This is related to differences in living environment and behavioral patterns, *etc.* Compared with the recommended values of other countries, the survey value of Baiyangdian Lake is lower than that of the United States (80.0 kg)^[12] and Australia (78.0 kg)^[12], and similar to that of the European Union (70.0 kg)^[12]. This reflects the influence of race, diet, and genetic factors.

Table 1 Recommended BW value for special investigation by the Ministry of Environment of China kg

Region	Urban-rural	Urban	Rural	Mean
Hebei Province	66.3	68.1	64.7	66.4
National	60.6	62.0	59.7	60.8

3.1.2 DI. The survey results show that the per capita daily drinking water intake of residents in inner-lake villages of Baiyangdian Lake is 1.834 L/d, which is basically consistent with the recommended value of 1.850 L/d in the *Guidelines*. Compared to international standards, the EU recommends a value of 2.000 L/d, and the US Environmental Protection Agency recommends a value of 2.400 L/d. This regional difference is mainly due to significant differences in climate conditions, dietary structures, and social culture between the East and the West.

3.1.3 FI. The survey results show that the FI of residents in inner-lake villages of Baiyangdian Lake is 0.079 5 kg/d, significantly higher than the recommended value of 0.023 7 kg/d in the *Guidelines*. Compared with international standards, the FIs in the United States and Europe are 0.02 and 0.115 kg/d^[12]. This may be significantly related to watershed characteristics, regional resource endowments, and dietary habits.

3.2 Bioaccumulation factor (BAF) The field measurement method is the preferred method for obtaining the regional bioaccumulation factor. When constructing mathematical models for water quality criteria, BAF plays a core role, and its scientific connotation lies in quantifying the dynamic process of biological enrichment of specific water pollutants transmitted through the aquatic food chain and ultimately formed in the edible parts of aquatic products commonly ingested by residents. When deriving BAF, it is necessary to determine the concentration of the pollutant in the water environment and the concentration of the pollutant in edible muscle tissue of aquatic products, and calculate the ecological cumulative effect of the pollutant on the environment. Based on the hydrophobicity, metabolic characteristics, and biomagnification effects of pollutants, the corresponding program in the *Guidelines* is selected to derive BAF. There are four deriving methods in the

programs, among which the field measurement method is applicable to any pollutant and is the preferred recommended method for all programs. Therefore, water and fish samples are collected from the natural water bodies of the Baiyangdian ecosystem, and priority is given to selecting fish with high consumption frequency by local residents as research objects to improve the regional representativeness of parameters. In this paper, a total of six fish species are selected, including *C. carpio*, *C. auratus*, *H. molitrix*, *P. fulvidraco*, *C. argus*, and *Ctenopharyngodon idella*, as shown in Table 2. By conducting indoor enrichment experiments, the BAF values of different trophic levels are measured.

Table 2 Fish in Baiyangdian Lake

Trophic level	Fish
II	<i>C. idella</i>
	<i>H. molitrix</i>
III	<i>C. carpio</i>
	<i>C. auratus</i>
	<i>P. fulvidraco</i>
IV	<i>C. argus</i>

4 Conclusions and prospects

The overall research on human health water quality criteria in China started relatively late, with prominent problems such as insufficient regional adaptability and weak localized basic data. As a unique shallow water grass lake in North China, Baiyangdian Lake has shallow water, slow exchange, and strong biological enrichment ability, and intake of aquatic products by surrounding residents is high. It is urgent to establish regional human health water quality criteria for pollutants with potential health risks. In this paper, the most appropriate method for obtaining technical parameters was adopted, and localized calibration of key parameters was carried out, providing reference for the prevention and control of water environment health risks in Baiyangdian Lake and the establishment of criteria for similar watersheds. In the future, the scope of criteria derivation for pollutants can be further clarified, local databases can be improved, and survey sample sizes can be expanded. It can enhance the accuracy and applicability of criteria derivation, and promote the transformation of criteria into standards and control schemes, to ensure the water environment safety and residents' health of Baiyangdian Lake.

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3.2 Research limitations and prospects This research is currently at the theoretical conception stage. All design plans and expected outcomes need to be verified through real teaching practice. Subsequent research will proceed along the following directions. Firstly, this plan will be proposed as a school-level or provincial-level educational reform project, and a cross-disciplinary teaching team will be established to conduct pilot teaching in 1 – 2 natural classes. Secondly, mixed research methods such as questionnaire surveys, in-depth interviews, and performance comparisons are used to collect empirical data and test the reform effectiveness. Thirdly, based on the feedback from the pilot, the teaching model will be continuously optimized, and the promotion paths in different majors (such as ecology and agriculture) in ethnic universities will be explored. In the future, the exploration of teaching reform rooted in the cultural soil of ethnic groups and integrating modern educational concepts will surely play a unique and important role in cultivating "reliable, employable, and competent" applied talents in ethnic regions.

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