ANALYSIS OF THE IMPACT OF LAKE ENVIRONMENTAL WATER POLLUTION ON THE HEALTH OF OUTDOOR SWIMMERS BASED ON STIRPAT ENVIRONMENTAL IMPACT ASSESSMENT MODEL

Xiaogang Gong*

Information and Communication Branch of State Grid Zhejiang Electric Power Co., Hangzhou, Zhejiang, 310000, China

gongxiaogang@foxmail.com

Xinyu Wu

Information and Communication Branch of State Grid Zhejiang Electric Power Co., Hangzhou, Zhejiang, 310000, China

Xuxiang Zhou

Information and Communication Branch of State Grid Zhejiang Electric Power Co., Hangzhou, Zhejiang, 310000, China

Reception: 14/11/2022 **Acceptance**: 16/01/2023 **Publication**: 02/03/2023

Suggested citation:

G., Xiaogang, W., Xinyu and Z. Xuxiang. (2023). **Analysis of the impact of lake environmental water pollution on the health of outdoor swimmers based on STIRPAT environmental impact assessment model**. *3C TIC. Cuadernos de desarrollo aplicados a las TIC, 12(1)*, 132-150. https://doi.org/10.17993/3ctic.2023.121.132-150

https://doi.org/10.17993/3ctic.2023.121.132-150

ABSTRACT

With the continuous development of China's economy, outdoor swimming has become an indispensable sport for Chinese people thereupon. However, the pollution of the outdoor water environment is capable of directly affecting the physical health of outdoor swimming lovers. Given the above, this paper uses the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model to analyze the environmental water pollution of lakes and study the influencing factors and degree of physical health of outdoor swimming crowds. Moreover, this paper also identifies the causes of water pollution in two respects, namely water pollution and human pollution and analyzes from the perspectives of water quality monitoring environment survey and questionnaire survey. The results show that the primary factors affecting water quality contain weather, swimming crowd density and environmental pollution around water areas, lake waters have direct and indirect effects on human health, and the incidence of eye inflammation, itchy skin, stuffy nose, sore throat, stomachache, nausea, earache, diarrhea, fever and vomiting are 36.4%, 30.3%, 29.5%, 26.5%, 21.2%, 20.1%, 20.1%, 17.0%, 14.8% and 12.9% respectively.

KEYWORDS

Water environment pollution; Outdoor swimming; Sports crowd; Influence study; Water quality monitoring.

https://doi.org/10.17993/3ctic.2023.121.132-150

PAPER INDEX

https://doi.org/10.17993/3ctic.2023.121.132-150

1. INTRODUCTION

With the continuous progress of science and technology, the ability of human beings to intervene in nature is getting stronger and stronger. The natural environment on which human beings depend for survival and development is also under enormous pressure [1]. Various activities of human society discharge pollutants into the environment, which not only seriously threaten human health, cause property loss, but also damage the environmental resources themselves [2-3].

In recent years, the number of environmental pollution damages caused by water pollution has risen sharply [4-5]. Such as the cadmium pollution incident in Beijing, Guangdong in December 2005, the arsenic pollution incident in Yueyang, Hunan in September 2006, the arsenic pollution incident in Yangzonghai in September 2008, the Yancheng pollution incident in Jiangsu in February 2009, and the arsenic pollution incident in July 2010. Zijin Mining Pollution Incident and Dalian Oil Spill Incident [6-7].

According to reports from the State Environmental Protection Administration system, yearbooks, journals, literature and online media, between 2005 and 2010, 95 major environmental pollution accidents were committed. Water pollution incidents caused by pollutant discharge have become an important type of accident that causes damage to the water environment [8-9].

In recent years, a large number of scholars at home and abroad have carried out related research on water environment pollution. Literature [10] has some innovations in the overall theory of water environmental pollution. They break the traditional way of thinking about water governance and use the theory of sustainable development to explore new water pollution management models. They believe that achieving effective protection and sustainable development is the focus of water pollution control and improvement. They pointed out that to achieve water pollution control, we must carry out the overall system and institutional innovation. Literature [11] and [12] put forward the following viewpoints from the perspective of comprehensive management: they believe that the management of water environment pollution is an important part of human production activities. Comprehensive treatment is the most powerful weapon for water pollution control. Literature [13] introduced the market governance method into the process of water environment governance, emphasizing the coordinated governance of various departments. Emission trading theory is a theoretical development in the process of water environment pollution control. In terms of governance methods, the literature [14] and [15] creatively put forward a new concept. He believed that the previous water environment pollution control was an all-powerful government-style governance. In the process of water pollution control, the role of market participation has been emphasized. The main role of the people is emphasized here, and it is hoped that the public can actively participate in water pollution control. Literature [16] focuses more on the idea that the government guides the whole society to govern, and believes that the degree of cooperation and coordination between all parties in the society is an important factor affecting the realization of high efficiency. References [17] and [18] believe that a government, market, enterprises, farmers and social organizations can be constructed to participate in the network governance mechanism of water pollution. Reference [19]

https://doi.org/10.17993/3ctic.2023.121.132-150

introduces an environmental penalty function based on the evolutionary game model analysis. Using this model, the distribution of water pollution loads in the Zarjub River in northern Iran was analyzed. Reference [20] analyzes the influencing factors of rural water pollution from the legal level. They argue that there is a Chinese rural water pollution legislation dependent on the cities. References [21] and [22] compared the investment in urban and rural environmental pollution control in 2013, and found that the focus of water environmental pollution control is in cities, while the rural water environment pollution control lacks investment. The study also shows that the uneven distribution of urban and rural areas leads to significant differences in the effects of urban and rural water pollution control. Literature [23], from the perspective of urban development, believes that the acceleration of urbanization has changed the quality and spatial distribution of water resources. Reference [24] took Hanji Township, Hubei Province as a case study object, and tested the water quality of Hanji Township. The main causes of water pollution are agricultural pollution, industrial pollution, domestic sewage, and waste pollution. Finally, the management countermeasures and suggestions are put forward. Reference [25] focuses on the current situation of rural drainage facilities and proposes that the lack of rural drainage facilities leads to improper sewage treatment, resulting in serious damage to the rural water environment. Reference [26] starts from the institutional mechanism of rural water environmental protection and proposes that the current rural water environmental protection mechanism has gradually become rigid. Reference [27] starts with the current situation of rural residents' understanding of water law and finds that rural residents lack access to knowledge of water law. It can be seen that scholars from all over the world regard water environment pollution as a major problem that affects the sustainable development of society and economy and affects people's life and health. Therefore, while promoting social and economic development, we must also do a good job in the protection of the water environment. This has become an important theme of economic development and reform in the new era [28-30].

With the rapid development of China's economy, people pay more and more attention to the spiritual world. Outdoor sports have become indispensable sport for the Chinese people. Outdoor swimming is especially sought after by outdoor sports enthusiasts. Therefore, whether the water environment is polluted or not will directly affect the health of outdoor swimming enthusiasts. This paper takes the water environment of a suburban lake in a city in China as an example to study the impact of typical water environment pollution on outdoor tourism and sports people. The purpose is to analyze the pollution of the lake water environment in the suburbs of a city and to study the impact on the outdoor swimming population after the water environment is polluted.

2. MATHEMATICAL MODELS AND DATA SOURCES

In studying the influencing factors of water environmental pollution, some researchers use different models to demonstrate. Different scholars have analyzed the influencing factors and their degree of influence. In recent years, the research on the STIRPAT model has become more and more extensive, and it is mainly applied to

https://doi.org/10.17993/3ctic.2023.121.132-150

environmental problems caused by carbon emissions and energy consumption. In the research on water environment pollution, some scholars have used the STIRPAT model to analyze the influence factors and degree of influence of water environment pollution on the health of the outdoor swimming population.

2.1. STIRPAT MODEL

The STIRPAT model refers to an extensible and random environmental impact assessment model. This paper will use this model in the subsequent empirical analysis to empirically analyze the environmental pollution of lakes in the suburbs of a city, the factors that affect the health of outdoor swimming people and their degree of influence. The STIRPAT model is an extension of the IPAT model. The initial form of the model can be expressed as:

$$I = P \times A \times T \tag{1}$$

In the above formula, I is the environmental pressure, P is the number of swimmers, A is the wealth of a city, and T is the technological progress.

The model believes that the environmental pressure I is determined by the scale of the number of swimmers P, the affluence of a city A, and technological progress T. Due to the limitations of this model in the application, many scholars have modified the nonlinear regression model STIRPAT model obtained by the IPAT model. The standard form of the model can be expressed as:

$$I = aP^b A^c T^d e \tag{2}$$

The above formula, I, P, A and T respectively represent the same meaning as formula (1), a, b, c and d the model influence coefficient and the index of each variable respectively, e is the random error term. In practical applications, to reduce the influence of heteroscedasticity, logarithm processing is performed on both sides of the formula (2). To facilitate the expression of each coefficient, it is expressed by β. After processing, a linear model is obtained. The linear model can be expressed as:

$$ln\ I = \beta_0 + \beta_1\ ln\ P + \beta_2\ ln\ A + \beta_3\ ln\ T + e \tag{3}$$

The above linear model was used to realize the analysis of factors affecting the health of the outdoor swimming population by water environment pollution.

2.2. DATA SOURCES

Water pollution is mainly caused by population growth, rapid social and economic development, and accelerated urbanization [31]. To comprehensively study the influencing factors and degree of influence of China's water environment pollution, this paper adds industrial structure, water consumption structure, urbanization and other indicators based on formula (3), so formula (3) is further extended to formula (4), that is, the extended linear regression equation of the STIRPAT model can be expressed as:

$$ln\ I = \beta_0 + \beta_1\ ln\ P + \beta_2\ ln\ A + \beta_3\ ln\ T + \beta_4\ ln\ ur + \beta_5\ ln\ st + \beta_6\ ln\ cs \tag{4}$$

https://doi.org/10.17993/3ctic.2023.121.132-150

Formula (4), I is the water environment quality. In this paper, the total amount of wastewater discharge, COD value and ammonia nitrogen discharge is used as water pollution indicators; P is the population size; A is the wealth level, expressed by per capita GDP; T is the technical level, expressed by the intensity of wastewater discharge; ur is the urbanization rate, expressed by the proportion of the urban population to the total population; st is the water consumption structure, expressed by the proportion of domestic water consumption to total water; cs is the industrial structure, expressed by the industrial output value Expressed as a percentage of GDP.

When China studies water pollution, the main statistical indicators include total wastewater discharge, COD discharge and ammonia nitrogen discharge [32]. According to the research on water environment pollution by Chinese scholars, this paper uses the total amount of wastewater discharge, COD discharge, and ammonia nitrogen discharge as indicators to measure China's water environment pollution, and conducts model test analysis with various water environment pollution factors. The degree of influence of environmental pollution factors on water pollution [33]. The water environment pollution evaluation index system is shown in Table 1.

Table 1. Evaluation index system of water environment pollution

Criterion layer	Indicator layer	Interpretation of indicators
Outdoor swimmers on the rise	Number of people swimming outdoors (P)	Minimum number of swimmers
Socioeconomic development	Urban affluence (A)	GDP per capita
	Techinque level (T)	Wastewater discharge intensity
	Urbanization rate (ur)	The proportion of the number of swimmers to the total number of people
	Industrial structure (cs)	Industrial output as a share of GDP
Swimmers swimming habits	Swimming habits (st)	The proportion of domestic water consumption in total water

The data comes from the 2009-2018 "China Statistical Yearbook", "China Environmental Statistical Yearbook" and the statistical yearbooks of various provinces, municipalities and autonomous regions.

https://doi.org/10.17993/3ctic.2023.121.132-150

3. CHARACTERISTICS AND CAUSES OF WATER POLLUTION

3.1. CHARACTERISTICS OF WATER ENVIRONMENT POLLUTION

The water pollutants in the lake area in the suburbs of a city are mainly phosphorus and nitrogen indicators. Judging from the monitoring results of the four factors of total phosphorus, total nitrogen, transparency and PH value, which are the evaluation indicators of the nutritional status of the lake, the lake water in the suburban lake area of a certain city is still in a state of eutrophication, with the appearance of periodic intensive growth of aquatic plants and peculiar smell in the water body, resulting in the deterioration of the lake water environment quality in the suburban lake area of a city and affecting the landscape of the lake area [34]. In terms of time distribution, the pollution degree in the suburban lake area of a certain city has strong regularity, and it mostly occurs between May and July every year, in terms of spatial distribution, artificial lakeshore areas are the main areas.

3.2. ANALYSIS OF CAUSES OF WATER ENVIRONMENT POLLUTION

3.2.1. WATER POLLUTION

Water eutrophication is a phenomenon of water pollution caused by excessive nitrogen, phosphorus and other nutrients in the water body. Crazy growth destroys the flow of material and energy in the system and gradually deteriorates the water ecosystem.

In the water body of a suburban lake area of a city, the external input of nutrient salts and the release of nutrients in the bottom of the lake area are important factors that cause the water quality in the lake area on the outskirts of a city to show a rich state, and at the same time, the eutrophication of natural water bodies is related to the changes in physical factors such as light, temperature, and dissolved oxygen [35].

The water in a lake area in the suburbs of a city is eutrophic, which mostly occurs from May to July every year (usually during stratification in summer). At this time, there is sufficient sunshine and the highest ambient temperature during the day is generally maintained in the range of 25°C-33°C, basically meeting the external climatic conditions of water eutrophication.

Nutrients such as phosphorus, nitrogen, etc. in the lake water body mainly come from the following aspects:

https://doi.org/10.17993/3ctic.2023.121.132-150

(1) The phosphorus released by the dead aquatic organisms and the decaying rhizomes of aquatic plants in the lake, and its humus is deposited on the bottom of the water, resulting in the enrichment of nutrients, and released under specific environmental conditions, resulting in the water quality of the lake area is rich in nutrients, this phenomenon is especially directly affected by phosphorus. In the water body of a lake area on the outskirts of a city, the change in phosphorus content will directly dominate the production of a certain type or several types of aquatic plants, and when phosphorus is the limiting factor, the increase of phosphorus will create favorable conditions for the large reproduction of aquatic organisms such as aquatic plants, directly affecting the degree of eutrophication of water quality [36].

(2) The mass reproduction and death of aquatic organisms such as aquatic plants will consume a large amount of oxygen in the water body, resulting in further deterioration of water quality. The decrease of dissolved oxygen in various water layers in the lake area was significantly related to the increase in total phosphorus content. Nutrients at all levels in the lake will release nitrogen and phosphorus when they secrete, excrete, and transform and release organic matter, which is also the source of nutrients. During the transformation and release of organic matter, at the same time as bacteria decompose them, it is returned to water bodies and sediments to be released under specific environmental conditions. The faster the aquatic plants reproduce and the more vigorous the activity, the more they will promote the release of nitrogen and phosphorus in the substrate.

(3) The supply of lakes and lakes in the suburbs of a city mainly comes from the surface water in the suburbs of a city, and the water also contains excess nitrogen, which mainly comes from the excessive application of fertilizers, agricultural wastes and domestic pollutants in agricultural production. Surface water mainly exists in the form of phosphate [37].

(4) Some tourists have uncivilized travel habits. Tourists throw bait and garbage into the lake area at will and artificially add phosphorus and nitrogen to the lake area.

3.2.2. HUMAN POLLUTION

Pollution is caused by the swimmer's secretions, excrement, etc. to the water body when swimming. In addition, it also includes that after people with certain infectious diseases or bacteria (viruses) enter the swimming pool, pathogenic factors are brought into the swimming pool, mainly from the digestive tract and body surface of the swimmer. Such as saliva, sweat, urine, tears and other secretions and excretions. The specific sources are the following:

(1) Urinary leakage occurs when the bladder contracts involuntarily due to cold contraction, and the amount of urine leakage for adults is generally 50ml. According to the survey, those who urinate during swimming account for about 3.5~5.0% of the swimmers, that is, one person urinates for every 20 swimmers. The more swimmers in the pool, the higher the urination rate, so urine is one of the main sources of swimming pool water pollution [38-39].

https://doi.org/10.17993/3ctic.2023.121.132-150

(2) Swimmers spit the water from the entrance into the pool together with saliva from time to time when swimming. The saliva may contain pathogenic bacteria or viruses, thus causing the pollution of the swimming pool water quality.

(3) Sweat is also a source of pool water pollution. According to Japan's Liuye report, the average person sweats 100ml/h when swimming in summer, and the amount of sweat increase with the increase of exercise. Although the amount of tear and other secretions is small, because there are often a variety of pathogenic factors such as germs and viruses in these secretions, it is also an important factor in polluting the water environment.

(4) In addition, the CO_2 in the exhaled breath of the swimmer, together with the secretions and excrement of the human body, can change the PH value of the water quality in the water environment, thus affecting the sanitation of the water quality.

4. RESULTS AND ANALYSIS

To analyze the impact of water environmental pollution on the outdoor swimming population, this paper conducted a water quality test on the lake waters in the suburbs of a city and investigated the waters and the surrounding environment. At the same time, the outdoor swimming population was divided into a swimming group and a non-swimming group, and a questionnaire survey and statistical analysis were carried out for these two groups.

4.1. WATER QUALITY MONITORING AND ENVIRONMENTAL SURVEY RESULTS

4.1.1. WATER QUALITY MONITORING METHODS

According to the "Technical Regulations for Lake Water Environment Monitoring" (2002), 3 monitoring points are set up in the suburban lake waters, among which monitoring point 1 is a peripheral point susceptible to pollution, monitoring point 2 is a crowded area, and monitoring point 3 is a less polluted area. In deep water points, 2 parallel samples were collected from each monitoring point. From 3 to 5 pm from May 28 to June 3, 2021, by GB 17378.4-1998 "Lake Monitoring Specification Part 4: Lake Water Analysis", sampling and microbial and physical index analysis was carried out, using C200 type automatic water quality analysis Instrument for general chemical index analysis. Detection indicators include fecal coliforms, color, transparency, PH, dissolved oxygen, salinity, floating matter and chemical oxygen consumption (COD).

4.1.2. ENVIRONMENTAL SURVEY RESULTS

There is basically no industrial and agricultural sewage discharge near the lakes in the suburbs of a city, and there is scattered non-point source pollution, which is mainly

https://doi.org/10.17993/3ctic.2023.121.132-150

caused by the domestic garbage brought by restaurants and tourists washed by rainwater. Therefore, changes in weather conditions and the number of tourists are the main reasons for the changes in pollutant discharge. The maximum number of people during the investigation period is 500-800 person-times, and the minimum is 100-200 person-times. 42 lake water samples were collected, and the lake water chromaticity was normal. The chromaticity of monitoring points 1, 2, and 3 were (15.00±3.90), (14.28±1.20), and (11.42±1.45) NTU, from near-land point to deep water. The point gradually becomes smaller; the PH value is 8.01~8.10; the salinity is 31‰~33‰; the transparency is >30cm, the water temperature is normal, and there is no thermal pollution source around. Table 2 shows the water quality test results of each monitoring point in the suburban lakes of a city.

Table 2. The water quality test results of each monitoring point in the suburban lakes of a city

Monitoring points	PH value	Chroma (NTU)	Dissolved oxygen (mg/L)	Nitrate nitrogen (mg/L)	COD (mg/L)	Inorganic nitrogen (mg/L)	Fecal coliforms (pcs/L)
Monitoring points1	8.10±0.08	15.00±3.90	6.51±2.16	0.16±0.02	2.70±0.14	0.21±0.02	36.0±7.60
Monitoring points2	8.09±0.07	14.28±1.20	5.60±2.01	0.17±0.03	3.40±0.14	0.19±0.02	36.0±6.07
Monitoring points3	8.01±0.10	11.42±1.45	6.71±1.90	0.16±0.03	3.05±0.09	0.21±0.03	35.0±6.69

Table 2 shows that in terms of dissolved oxygen and oxygen-consuming substance content, the dissolved oxygen content of monitoring points 1 and 3 are (6.51 ± 2.16) and (6.71 ± 1.90) mg/L, respectively, reaching the lake water quality class I standard. Monitoring point 2, the dissolved oxygen content is (5.60±2.01) mg/L, which meets the II water quality standard. The chemical oxygen consumption (COD) of monitoring points 1, 2, and 3 were (2.70±0.14), (3.40±0.14) and (3.05±0.09) mg/L in turn, reaching the lake water quality class II standard.

In terms of nitrogen content, inorganic nitrogen can indicate the status of lake water being polluted by domestic wastewater, etc., and ammonia nitrogen exceeding the standard indicates the existence of new pollution. The inorganic nitrogen of 2 samples exceeded the standard of class II lake water, and the exceeding rate was 4.7%, indicating that the seawater was recently polluted. The nitrate nitrogen content of monitoring points 1, 2 and 3 is 0.16 mg/L~0.17 mg/L, and the inorganic nitrogen content is 0.05 mg/L~0.45 mg/L.

In terms of biological indicators, there is no suspended matter in the lake water in the suburbs of a certain city, and there is white suspended matter in the lake water at certain times, mainly jellyfish, which are unique to the region in May and June. Fecal coliforms <156/L, reaching the class I standard of lake water quality.

The results of this survey show that the inorganic nitrogen in the lake water reaches the standard of lake water category II and meets the requirement of swimming water. Dissolved oxygen, fecal coliform and PH value can reach the standard of lake water category I. The results of the environmental survey of the lake water show that there

https://doi.org/10.17993/3ctic.2023.121.132-150

is surface source pollution such as the catering industry in the lake area, and the dissolved oxygen content in the water is (1.63±0.63) mg/L. The density of swimmers at monitoring point 2 is the largest, and the dissolved oxygen content in its water is the lowest, at (5.60±2.01) mg/L. Therefore, the weather, the density of swimmers and the environment around the lake water are the main factors affecting water quality.

4.2. QUESTIONNAIRE SURVEY AND RESULTS

4.2.1. QUESTIONNAIRE SURVEY METHOD

The field population in a suburban lake was taken as the survey object, and the questionnaire was formulated and revised according to the actual situation. The questionnaire contains a total of 42 individual choices, which are divided into two parts: the on-site questionnaire survey and the follow-up questionnaire after 7 days. The contents of the investigation included whether there were any changes in the respiratory tract, digestive tract, eyes, ears, nose, chest tightness, tinea pedis, skin infection symptoms and changes in mental state, which were completed within 2 consecutive days. The follow-up questionnaire was conducted by telephone, E-mail, QQ group, WeChat group, etc., and was conducted 7 days after the on-site investigation.

The investigators of this questionnaire survey are all trained and qualified medical students. Before the survey, 60 members of the swimming association and 50 students of the school were organized to conduct a preliminary survey, and the questions in the survey questionnaire were improved. Unify the standards during the investigation, and eliminate abnormal data during data entry. Monitoring data are represented by $\bar{x} \pm s$. Through the above STIRPAT environmental impact assessment model, the health influencing factors and influence degree of the outdoor swimming population were assessed. SPSS 10.0 statistical software was used for data entry, and x^2 test and Logistic regression analysis was performed. The difference was statistically significant $P < 0.05$.

4.2.2. INFLUENCE ON THE HEALTH OF THE SWIMMING POPULATION

A total of 500 questionnaires were distributed in this survey, 491 were recovered, 408 were valid questionnaires, and the response rate was over 90%. In this paper, the population was divided into swimming and non-swimming groups, and on-site questionnaires were administered to the swimming and non-swimming groups, respectively. Follow-up questionnaires were conducted again after 7d. The results of the survey were summarized for both groups and finally, the number of people in both groups who developed symptoms and the incidence were analyzed. A comparison of the incidence of different symptoms in the swimming and non-swimming groups is shown in Figure 1.

https://doi.org/10.17993/3ctic.2023.121.132-150

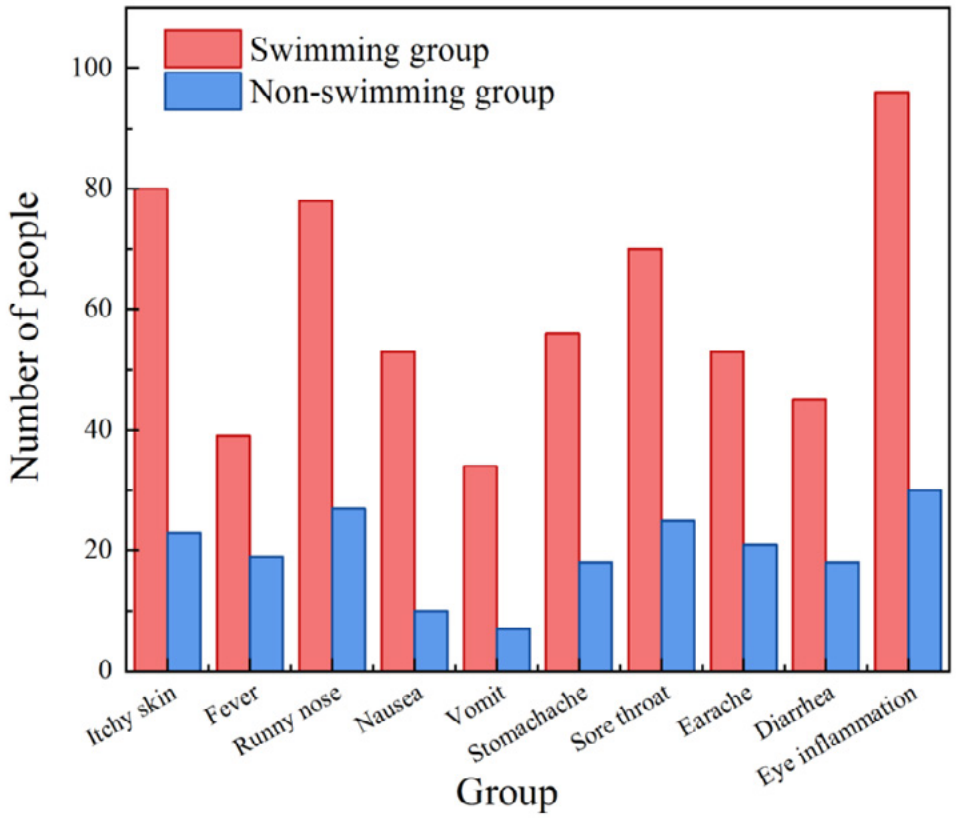

Figure 1. Comparison of the incidence of different symptoms between the swimming group and the non-swimming group.

As can be seen from Figure 1, 264 people in the swimming group suffered from itchy skin, fever, nasal congestion, runny nose, nausea, vomiting, stomach pain, sore throat, earache, diarrhea and eye inflammation, while the number of people in the non-swimming group found such symptoms for 144 people. In addition, the number and incidence of any symptom in the swimming group were higher than those in the non-swimming group. The most obvious one was: in terms of skin itching symptoms, the number and incidence of the swimming group were 57% higher than those in the non-swimming group. people, 14.3%. In terms of nasal congestion and runny nose, the number and incidence of the swimming group were 51 and 10.7% higher than those of the non-swimming group. In terms of symptoms of nausea, the number and incidence of the swimming group were 43 and 13.2% higher than those of the non-swimming group. In terms of inflammation, the number and incidence of the swimming group were 57 and 14.3% higher than those of the non-swimming group, respectively.

According to the above data, the number and incidence of skin itching, fever, nasal congestion, runny nose, nausea, vomiting, stomach pain, sore throat, earache, diarrhea and eye inflammation in the swimming group were higher than those in the non-swimming group. The incidences of itching, nasal congestion and runny nose, nausea, vomiting, stomach pain, sore throat, eye inflammation and diarrhea were significantly different ($P < 0.05$ or $P < 0.01$), while there was no statistical difference

https://doi.org/10.17993/3ctic.2023.121.132-150

in the incidence of fever and earache between the two groups. academic significance ($P < 0.05$).

4.2.3. LOGISTIC REGRESSION ANALYSIS OF RISK FACTORS AFFECTING THE HEALTH STATUS OF THE SWIMMING POPULATION

Taking the symptoms of the population (whether there is the respiratory tract, digestive tract, eyes, ears, nose, chest tightness, tinea pedis, skin infection symptoms and mental state, etc.), wearing earplugs, swimming goggles, etc.) were used as independent variables, and a two-class logistic regression analysis was performed. The logistic regression multivariate analysis of the risk factors for the health status of the swimming population is shown in Table 3.

Table 3. Logistic regression multivariate analysis of risk factors for the health status of the swimming population

Symptom	Influencing factors	βvalue	SE	Wald value	P value	OR value	95%CI
Itchy skin	Swim	1.367	389	12.337	0	3.925	1.830-8.417
	Swallow lake water	1.392	424	10.771	1	4.023	1.752-9.236
Eye inflammation	Swim	0.93	317	8.618	3	2.535	1.362-4.718
	Not wearing diving glasses	889	332	7.193	7	2.433	1.271-4.661

Table 3 shows that the main risk factors for skin itching symptoms in the population include swimming (OR value 3.925, 95%CI: 1.830-8.417) and swallowing lake water (OR value: 4.023, 95%CI: 1.752-9.236). Statistical significance ($P < 0.01$), which indicates that swimming and swallowing lake water sentences can increase the risk of skin itching in the population; the risk factors for eye inflammation in the population include swimming (OR value: 2.535, 95%CI: 1.362~4.718) and swimming Without diving glasses (OR value: 2.433, 95% CI: 1.271-4.661), the difference was statistically significant ($P < 0.01$), indicating that swimming and swimming without diving glasses can increase the risk of eye inflammation in the population.

5. DISCUSSION

The disposal of water environmental pollution incidents, especially the restoration and assessment of water environmental damage, is a blank field in China, and there is a lack of systematic research on the relevant assessment method systems. This paper takes the water environment of a lake in the suburbs of a city as an example to study the impact of the polluted water environment of the lake on the health of outdoor

https://doi.org/10.17993/3ctic.2023.121.132-150

sports swimmers. However, it does not involve the process of China's disposal of water pollution incidents, as well as the related content of the concept and assessment method of environmental damage assessment. Therefore, in the future research direction, it is mainly China's research on the disposal process of water environmental pollution incidents, the concept and assessment method of environmental damage assessment, which has important theoretical significance and technical support for the establishment of environmental damage restoration and assessment method system, the development of environmental damage assessment method practice, and the construction of environmental economic policy system. The protection of the water environment not only protects human survival, social progress and economic development, but also sustains the need for a good ecological environment. Lake bathing is best to wear waterproof goggles as well as ear plugs, etc., use water to rinse the whole body immediately after bathing and use eye drops and ear drops for prevention if necessary. At the same time, we should strengthen the monitoring of the density of the swimming crowd and control the surface source pollution to protect the physical and mental health of the crowd.

6. CONCLUSION

This paper takes the water environment of a suburban lake in a city as an example to study the impact of the polluted water environment on the health of outdoor sports swimmers. And analyzed from two aspects of water quality monitoring and questionnaire survey. Finally, the influencing factors of water environment pollution on the outdoor tourism population are studied:

(1) Judging from the results of water quality monitoring and environmental investigation, the inorganic nitrogen in the waters of the lake reaches the class II standard of lake water, which meets the requirements for swimming water. Dissolved oxygen, fecal coliform and PH value can reach the class I standard of lake water. The survey results of the lake water environment show that there is non-point source pollution such as food and beverages near the lake waters, especially on rainy days, and the dissolved oxygen content in the water is (1.63±0.63) mg/L. The density of swimmers at monitoring point 2 was the highest, and the dissolved oxygen content in its water was the lowest, which was (5.60±2.01) mg/L, which shows that weather, swimming population density and environmental pollution around the water are the main factors affecting water quality.

(2) According to the questionnaire survey, lake waters have direct and indirect effects on people's health (including skin, respiratory tract, stomach, eyes, ears, etc.). The main symptoms are itchy skin, fever, nasal congestion, runny nose, nausea, vomiting, stomach pain, sore throat, earache, diarrhea, and eye inflammation.

(3) The results of the questionnaire survey show that polluted lake waters can have adverse effects on the health of the population. The main manifestations were eye inflammation at 36.4%, skin itching at 30.3%, nasal congestion and runny nose at 29.5%, sore throat at 26.5%, stomach pain at 21.2%, and nausea at 20.1%, the

https://doi.org/10.17993/3ctic.2023.121.132-150

incidence of ear pain was 20.1%, the incidence of diarrhea was 17.0%, the incidence of fever was 14.8%, and the incidence of vomiting was 12.9%.

It can be seen that the impact of lake water quality on the health of the population is related to the swimming habits of the swimming population. Lake bathing is best to wear waterproof goggles as well as ear plugs, etc., use water to rinse the whole body after bathing and use eye drops and ear drops for prevention if necessary. At the same time, we should strengthen the monitoring of the density of the swimming crowd and control the surface source pollution to protect the physical and mental health of the crowd.

7. DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/ supplementary material, further inquiries can be directed to the corresponding author.

8. CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

REFERENCES

(1) Tang W, Pei Y, Zheng H, et al. (2022). **Twenty years of China's water pollution control: Experiences and challenges**. *Chemosphere*, 295, 133875.

(2) Ren L, Lu Z, Xia X, et al. (2022). **Metagenomics reveals bacterioplankton community adaptation to long-term thermal pollution through the strategy of functional regulation in a subtropical bay**. *Water Research*, 216, 118298.

(3) He J, Zhang Y, Ni F, et al. (2022). **Understanding and characteristics of coagulation removal of composite pollution of microplastic and norfloxacin during water treatment**. *Science of The Total Environment*, 831, 154826.

(4) Yang J, Strokal M, Kroeze C, et al. (2022). **What is the pollution limit? Comparing nutrient loads with thresholds to improve water quality in Lake Baiyangdian**. *Science of The Total Environment*, 807, 150710.

(5) Riedel T, C Kübeck, Quirin M. (2022). **Legacy nitrate and trace metal (Mn, Ni, As, Cd, U) pollution in anaerobic groundwater: Quantifying potential health risk from "the other nitrate problem"**. *Applied Geochemistry*, 139, 105254.

(6) Yan C, Qu Z, Wang J, et al. (2022). **Microalgal bioremediation of heavy metal pollution in water: Recent advances, challenges, and prospects**. *Chemosphere*, 286(3), 131870.

(7) Niu Y H, Wang L, Wang Z, et al. (2022). **High-frequency monitoring of neonicotinoids dynamics in soil-water systems during hydrological processes**. *Environmental Pollution*, 292, 118219.

https://doi.org/10.17993/3ctic.2023.121.132-150

(8) Yu X, Huang W, Wang Y, et al. (2022). **Microplastic pollution in the environment and organisms of Xiangshan Bay, East China Sea: An area of intensive mariculture**. *Water Research*, 212, 118117.

(9) Yang Q, Liu Y, Wang L, et al. (2022). **Cerium exposure in Lake Taihu water aggravates microcystin pollution via enhancing endocytosis of Microcystis aeruginosa**. *Environmental Pollution*, 292, 118308.

(10) Liu Y, Wang P, Gojenko B, et al. (2021). **A review of water pollution arising from agriculture and mining activities in Central Asia: Facts, causes and effects**. *Environmental Pollution*, 291, 118209.

(11) Zhou, Z., Liu, J., Zhou, N., Xu, J., He, L., & Jiang, X. (2021). **Does the "10-Point Water Plan" reduce the intensity of industrial water pollution? Quasi-experimental evidence from China**. *Journal of Environmental Management*, 295, 113048.

(12) Wang, H., Yang, Q., Ma, H., Zou, Z., & Wang, L. (2021). **Chemical compositions evolution of groundwater and its pollution characterization due to agricultural activities in Yinchuan Plain, northwest China**. *Environmental Research*, 200, 111449.

(13) Dai, L., Lu, Q., Zhou, H., & Jiang, L. (2021). **Tuning oxygenated functional groups on biochar for water pollution control: A critical review**. *Journal of Hazardous Materials*, 420(Part 1), 126547.

(14) Zhang, Q. Q., Xing, C., Cai, Y. Y., Yu, K., & Liu, X. (2021). **How much do human and livestock actually contribute to steroids emission and surface water pollution from past to the future: A global research**. *Science of The Total Environment*, 772, 145558.

(15) Ishii, E., Watanabe, Y., Agusa, T., Fujihara, J., Yasuda, T., & Mizukawa, K. (2021). **Acesulfame as a suitable sewer tracer on groundwater pollution: A case study before and after the 2016 Mw 7.0 Kumamoto earthquakes**. *Science of The Total Environment*, 754, 142409.

(16) Ranjbar, R., Shariati, F. P., Tavakoli, O., & Dorraji, M. S. (2021). **Fabrication of a new reactor design to apply freshwater mussel Anodonta cygnea for biological removal of water pollution**. *Aquaculture*, 737077.

(17) Meng, X., Peng, X., Xue, J., Gao, C., & Liu, Y. (2021). **A biomass-derived, all-day-round solar evaporation platform for harvesting clean water from microplastic pollution**. *Journal of Materials Chemistry A*, 9.

(18) Haskins, D. L., Brown, M. K., Qin, C., Adams, L., & Hecker, M. (2021). **Multi-decadal trends in mercury and methylmercury concentrations in the brown watersnake (Nerodia taxispilota)**. *Environmental Pollution*, 274, 116722.

(19) Oehler, T., Ramasamy, M., George, M. E., & Reniers, A. J. (2021). **Tropical Beaches Attenuate Groundwater Nitrogen Pollution Flowing to the Ocean**. *Environmental Science and Technology*, 55(12).

(20) He, S., Wu, J., Wang, D., & Wen, Y. (2021). **Predictive modeling of groundwater nitrate pollution and evaluating its main impact factors using random forest**. *Chemosphere*, 290(2), 133388.

(21) Xia C, Liu G, Wang Z, et al. Distribution of hydrogen and oxygen stable isotopes and pollution indicators in water during a monsoon transitional period in Min River Basin[J]. Science of The Total Environment, 2021:146780.

https://doi.org/10.17993/3ctic.2023.121.132-150

(22) Kumar S. **Water resources pollution associated with risks of heavy metals from Vatukoula Goldmine region, Fiji**. Journal of Environmental Management, 2021.

(23) Payus C, Geoffrey I, Oliver A. (2018). **Retracted: Determination of free chlorine content in indoor and outdoor swimming pool sports complex**.

(24) Smith, C. C., Löf, G., & Jones, R. (2019). **Measurement and analysis of evaporation from an inactive outdoor swimming pool**. *Solar Energy*, 53(1), 3-7.

(25) Simard, S., Tardif, R., & Rodriguez, M. J. (2017). **Variability of chlorination by-product occurrence in water of indoor and outdoor swimming pools**. *Water research: A journal of the international water association.*

(26) Yao, S. (2020). **An investigation of haloacetic acid occurrence in indoor and outdoor swimming pools in Beijing China**. *IOP Conference Series: Earth and Environmental Science*, 467(1), 012136 (7pp).

(27) Pérez, P. A., Ballesteros-Gómez, A., Crespo-Lopez, M. E., et al. (2022). **The role of outdoor and indoor air quality in the spread of SARS-CoV-2: Overview and recommendations by the research group on COVID-19 and particulate matter (RESCOP commission)**. *Environmental Research.*

(28) Allen, J. M., Plewa, M. J., Wagner, E. D., et al. (2021). **Making Swimming Pools Safer: Does Copper-Silver Ionization with Chlorine Lower the Toxicity and Disinfection Byproduct Formation?** *Environmental Science & Technology*, 55(5).

(29) Anugerah, A. R., Muttaqin, P. S., & Purnama, D. A. (2021). E**ffect of Large-Scale Social Restriction (PSBB) during COVID-19 on Outdoor Air Quality: Evidence from Five Cities in DKI Jakarta Province, Indonesia**. *Environmental Research*, 197(Special Issue), 111164.

(30) Belosi, F., Conte, M., Gianelle, V., et al. (2021). **On the concentration of SARS-CoV-2 in outdoor air and the interaction with pre-existing atmospheric particles**. *Environmental Research*, 193, 110603.

(31) Li M, Lana C C, Tan C S, et al. (2021). **Association of time outdoors and patterns of light exposure with myopia in children**. *British Journal of Ophthalmology.*

(32) Hamid N A, Alexander N, Suer R, et al. (2020). **Targeted outdoor residual spraying, autodissemination devices and their combination against Aedes mosquitoes: field implementation in a Malaysian urban setting - ERRATUM**. *Bulletin of Entomological Research*, 110(6), 1.

(33) Rozema A D, Mathijssen J, Van K, et al. (2019). **Results of outdoor smoking bans at secondary schools on adolescents smoking behaviour: a quasi-experimental study**. *The European Journal of Public Health*, 29(4).

(34) Gartrell B D, Battley P F, Clumpner C, et al. (2019). **Captive husbandry and veterinary care of seabirds during the MV Rena oil spill response**. *Wildlife Research*, 46(7), 610.

(35) Magalhaes S, Baumgartner J, Weichenthal S. (2018). **Impacts of exposure to black carbon, elemental carbon, and ultrafine particles from indoor and outdoor sources on blood pressure in adults: A review of epidemiological evidence**. *Environmental Research*, 161(FEB.), 345-353.

https://doi.org/10.17993/3ctic.2023.121.132-150

(36) Wyse A, Rodrigues A, dos Santos A, et al. (2017). **Pregnancy swimming causes short- and long-term neuroprotection against hypoxia-ischemia in very immature rats**. *Pediatric Research.*

(37) Yoon I J, Hong J W. (2017). **Safety Equipment for Swimming Beaches in Korea: Implications for Management**. *Journal of Coastal Research*, 79, 1-5.

(38) Juárez, F. F., Esenarro, D., Díaz, M., & Frayssinet, M. (2021). **Model based on balanced scorecard applied to the strategic plan of a peruvian public entity**. *3C Empresa. Investigación y pensamiento crítico*, 10(4), 127-147. https://doi.org/10.17993/3cemp.2021.100448.127-147

(39) Chen, H., Peng, X., & Chen, C. (2022). **Corporate social responsibility fulfilment, product-market competition and debt risk: Evidence from China**. *Applied Mathematics and Nonlinear Sciences*, 7(2), 757-772. https://doi.org/10.2478/AMNS.2021.2.00163

https://doi.org/10.17993/3ctic.2023.121.132-150