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Evaluation of Water Quality of Fuxian Lake by Principal Component Analysis

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Abstract

In this study, five water quality indexes of chemical oxygen demand (COD) in fuxian Lake were analyzed by principal component analysis (PCA) with the help of SPSS software. The results showed that the cumulative variance contribution rate of principal component 1 and principal component 2 extracted from the original data was 83.716%. According to the comprehensive evaluation function, the comprehensive ranking of pollution degree of eight sampling points is obtained. In addition, through the comprehensive evaluation of the water quality of Fuxian Lake, the pollution degree can be classified into clean and still clean.

Keywords: Water Quality Evaluation, Fuxian Lake, SPSS, Principal Component Analysis

Introduction

Water is the source of life, is the condition of survival and development of human society to survive Plateau lakes functions significantly in regulating climate To improve the function of the ecological environment Fuxian lake is located in the core region of yunnan province, is China's second deep lake, is one of important strategic reserve freshwater resources in China, the ecological status, the pros and cons of the water quality of the surrounding people's life Local economic and social development have a significant impact. Studies have pointed out that the aquatic ecosystem of Fuxian Lake is single and fragile. In recent years, the development of surrounding tourism areas and the rapid development of industry and agriculture have increased the pollution into the lake [1,2]. In addition, the water exchange period of Fuxian Lake is long and the retention rate of pollutants is high, which leads to the decline of water quality of Fuxian Lake and the intensification of eutrophication. Water quality evaluation is an important part of water environment management, and scientific evaluation of water environment quality is an important basis for national economic development and human healthy life. At present, the commonly used water quality evaluation methods include: index evaluation method [3], Single factor evaluation method [4], fuzzy mathematical method [5], grey relational analysis [6] et.

Principal component analysis (PCA) is a multivariate statistical analysis method that integrates multidimensional factors into the same system for quantitative research, which can save original data and simplify data structure to the maximum extent and screen out important influencing factors[7].The main aim of this work is to use principal component analysis (PCA) to analyze the water environmental quality of Fuxian Lake, determine the correlation between the parameters considered, and find out the main indicators affecting water quality, in order to provide a basis for the management and protection of the overall water environmental quality of Fuxian Lake, and provide a reference method for the rapid and accurate evaluation of lake water quality.

Materials And Methods

Study Area

Fuxian Lake is located among three counties of Huaning County, Jiangchuan District, Chengjiang City, Yuxi City, Yunnan Province, in central Yunnan Province (24°29'~24°55' N, 102°47'~103°04'E), the water area is about 216.6 km^2, the maximum water depth is 155 meters, and the lake volume is about 20.62 billion m^3. The basin covers an area of 1084 square kilometers. The basin is fertile and rich in land, mainly producing rice, wheat, broad bean, tobacco and rape Its water resources are quite rich, with water storage of 18.5 billion cubic meters. The lake water can irrigate the fertile farmland along the coast, and there is navigation convenience.

Methods

Principal component analysis (PCA) is a multiple and has a certain correlation between indicators, using the method of dimension reduction of mathematical transformation into several comprehensive index, these a few comprehensive indexes are called principal components [8], there is no correlation between principal component is a linear combination of the original index, so the principal component can reflect the internal relations between original indexes, without overlapping [8] .The application of principal component analysis (PCA) in water environmental quality assessment mainly includes two aspects: on the one hand, the comprehensive evaluation index is established to evaluate the pollution degree of each sampling point, so as to rank the pollution degree of each sampling point , On the other hand, through the evaluation of the role of each single indicator in the comprehensive index, some secondary indicators are deleted to determine the main components causing pollution [9].

Data

According to the sampling principle of lake and the shape of the whole lake of Fuxian Lake, the characteristics of water area, near shore area, deep water area, near water area, etc. Starting from the SanWanShui (pumping station), directly to the north of the lake,

eight sampling points were selected clockwise from DaWan Village, Qingyuwan Lake Area, police station near shore, Hotel Lake Area, artificial lake near shore, jianshan toki coastal road, and central lake heart. In view of the large number of rivers entering Fuxian Lake and the dense population and agricultural production in the northern part of the lake, the main pollution sources are agricultural non-point sources and phosphate mining pollution [10]. In this paper, chemical oxygen demand (COD), biochemical oxygen demand for 5 days (BOD_5), total phosphorus, total nitrogen and ammonia nitrogen were selected as the evaluation index, and the monitoring average value of 2019 was used to evaluate the water quality.

sample point	COD	BOD_5	TP	TN	NH_4^+-N
SanWanShui (pumping station)	1.13	2.0	0.038	0.200	0.041
DaWan Village	1.18	1.4	0.005	0.180	0.033
Qingyuwan Lake Area	1.06	1.7	0.006	0.163	0.026
police station near shore	1.03	1.5	0.007	0.200	0.031
Hotel Lake Area	0.93	1.7	0.006	0.153	0.027
artificial lake near shore	1.26	1.8	0.005	0.160	0.025
jianshan toki coastal road	1.39	1.8	0.054	0.232	0.046
central lake heart	1.49	1.6	0.006	0.173	0.033

Table 1: Water Quality Monitoring Data of Fuxian Lake In 2019 mg/L

Results And Discussions

Principal Component Analysis

Principle of principal component selection: only the principal component corresponding to the Eigen Value λ>1 is selected [11]. The higher variance component, which provides more information about the data. In this paper, SPSS software was used to reduce dimension according to the steps of principal component analysis, and PCA was used to further divide the dimension into two components.PC1 and PC2 have Eigen values over 1 and a Cumulative Variances of 83.716%.It indicates that the two principal components can reflect 83.716% of the information provided by the original index data. Therefore, it can be determined that the two principal components should be extracted, and their characteristic values are respectively λ1=3.163 and λ2=1.023, as shown in Table 2.

	Minimum	maximum	Mean	Std.deviation	F1	F2
total phosphorus	0.005	0.054	0.016	0.019	0.435	-0.416
ammonia-nitrogen	0.026	0.046	0.033	0.007	-0.249	0.717
total nitrogen	0.153	0.232	0.183	0.027	0.159	0.328
BOD_5	1.4	2.0	1.69	0.189	0.341	-0.016
COD	0.93	1.49	1.18	0.245	0.319	0.061
Eigen Value					3.163	1.023
Variance					63.254	20.462
C.V(%)					63.254	83.716

Table 2: Summary of principal components, Eigen values and Variance

The variance of principal component 1 is 63.254%, which has a positive load on total phosphorus and total nitrogen, BOD_5, COD, and a negative loading on ammonia nitrogen. The variance of the second principal component is 20.462%, which has a positive loading on ammonia nitrogen, total nitrogen, COD and a negative loading on total phosphorus and BOD.

The chemical oxygen demand (COD), biochemical oxygen demand for 5 days (BOD_5), total phosphorus, total nitrogen, and ammonia nitrogen are respectively: X_1, X_2, X_3, X_4, X_5, according to the corresponding principal component load value [12], the principal component expressions are respectively:

$$F_1 = 0.319X_1 + 0.341X_2 + 0.435X_3 + 0.1594 - 0.249X_5$$

$$F_2 = 0.061X_1 - 0.016X_2 - 0.416X_3 + 0.328X_4 + 0.717X_5$$

According to λ1=3.163, λ2=1.023, the comprehensive evaluation function is calculated

$$F = [\lambda_1/(\lambda_1 + \lambda_2)]F_1 + [\lambda_2/(\lambda_1 + \lambda_2)]F_2 = 0.756F_1 + 0.244F_2$$

Physicochemical Parameter Analysis

The water quality classification standard from Paper 13 [13], as shown in Table 3, was used in this study to evaluate the pollution degree of different sampling points in the research area. Substitute the standardized data into the principal component expression to calculate the principal component value of each sampling point. Then, according to the comprehensive evaluation function, the comprehensive evaluation score of each sampling point is calculated with the variance contribution rate of each principal component as the weight [14]. Figure 1 shows the quantitative description of water pollution degree. The higher the score is, the more serious the pollution is [12].

Pollution classification	1	2	3	4	5	6
degree of contamination	clean	next to clean	mild pollution	medium pollution	heavy pollution	gross pollution
F	<0	0~2	2~4	4~6	6~15	>15

Table 3: Water quality classification

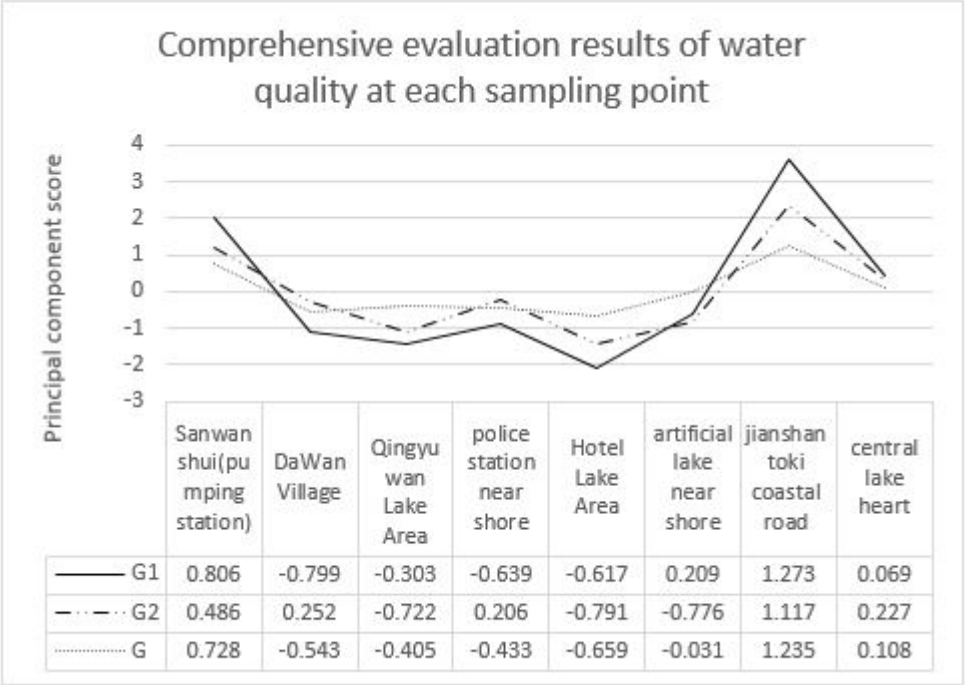

Figure 1: Comprehensive evaluation results of water quality at each sampling point

By figure 1 can get, fuxian lake pollution levels at eight sampling order from strong to weak was: jianshan toki coastal road, Sanwanshui (pumping station), central lake heart, artificial lake near shore, Qingyuwan Lake Area, police station near shore, DaWan Village, Hotel Lake Area. Among them, the pollution degree of artificial lake near shore, Qingyuwan Lake Area, police station near shore, DaWan Village, Hotel Lake Area is clean, and jianshan toki coastal road, Sanwanshui (pumping station), central lake heart is still clean.

G1 mainly reflects the pollution value of total phosphorus and ammonia nitrogen to water body: the G1 value of jianshan toki coastal road is the highest, and the pollution is relatively heavy, indicating that the main pollution factor in this area is total phosphorus and ammonia nitrogen. The second serious pollution is Sanwanshui (pumping station), artificial lake near shore, central lake heart, their pollution causes are the same as jianshan toki coastal road, mainly caused by N, P and other nutrients From G2, jianshan toki coastal road had a high score, this indicated that the BOD_5 was high in this area, followed by Sanwanshui (pumping station) and Dawan Village. The G1 of Dawan Village was the smallest, indicating that this area was only affected by total phosphorus and ammonia nitrogen. From the comprehensive score G, jianshan toki coastal road is still the highest score, investigate its reason, there is a red beach in the upstream of jianshan toki coastal road, there will be a large number of tourists playing in this water, tourists come at the same time, pollutants will follow, the negative effect of the upstream wetland park will intensify the pollution here. When the water body is polluted, it is necessary to take rescue measures to timely control the pollution sources and the spread of pollutants. The pollution in the hotel lake area is relatively light, which is due to the renovation of fuxian Lake hotel sewage in Yuxi city in recent years.

According to the actual water quality monitoring data, jianshan toki coastal road, Sanwan shui (pumping station) and central lake heart, these sites have higher biochemical oxygen demand index, total phosphorus and ammonia nitrogen. The monitoring index of total phosphorus and ammonia nitrogen in the coastal area of the artificial lake was relatively high, while the index of biochemical oxygen demand was low. The biochemical oxygen demand index of Dawan village was low, but the monitoring indexes of total phosphorus and ammonia nitrogen were relatively high, which proved that the results of principal component analysis could reflect the actual situation.

Conclusion

Principal component analysis shows that, among the five factors, two principal components can reflect 83.816% of the information provided by the original index data. According to the eigen valueλ_1 andλ_2, the comprehensive function is calculated as: $F = 0.756F_1 + 0.244F_2$,The principal component score determined that the pollution degree of the eight sampling points was ranked as: jianshan toki coastal road > Sanwanshui (pumping station) > central lake heart > artificial lake near shore > Qingyuwan Lake Area > police station near shore > DaWan Village > Hotel Lake Area. According to the water quality classification, the pollution level is divided into two categories: clean and still clean. Principal component analysis helps to identify more polluted area, the area based on different principal component scores were observed, the principal component analysis (pca) was applied to fuxian lake water quality evaluation, substitute a few principal components for original multidimensional variables and simplify the data structure, can determine the main pollutants, and could comprehensively reflect the index of each sampling point in lake comprehensive pollution level, for fuxian lake environmental governance It provides an important theoretical basis and a fast and accurate method for lake water quality evaluation.

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