Remote Sensing Inversion Study on Key Water Quality Parameters of Qinghai Lake

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Abstract: To select a suitable remote sensing inversion model for the concentration of chlorophyll-a, a key water quality parameter of Qinghai Lake, this study based on Landsat 8 remote sensing image data and combined with the measured chlorophyll-a concentration data, constructed an inversion model for chlorophyll-a concentration in Qinghai Lake, and explored the spatial distribution pattern of chlorophyll-a concentration in Qinghai Lake in July 2024. The results show that the bands with higher correlation with the chlorophyll-a concentration of this water body are Landsat 8's B1, B6, and B7 bands; the band combination B6-B7 has a high correlation with the natural logarithm of chlorophyll-a concentration; the root mean square error (RMSE) of the chlorophyll-a concentration inversion model constructed is 0.162 μg/L, and the mean absolute error (MAE) is 14.36%, with high accuracy and good applicability; in July 2024, the chlorophyll-a concentration in Qinghai Lake showed a characteristic of lower concentrations at the river mouths such as the Buhai River and higher concentrations in areas such as the Erliangxian coast.
Keywords: chlorophyll-a concentration; eutrophication; Landsat 8 remote sensing imagery; Qinghai Lake

1. Introduction

Since the 1930s, between 40% to 50% of lakes and reservoirs globally have seen varying levels of eutrophication, rendering the nutrification of aquatic systems a prevalent ecological crisis for lakes worldwide (Liu et al. 2022; Zhu et al. 2018; Ma et al. 2019). The swift proliferation of algae in aquatic environments is a direct consequence of eutrophication. Among various water quality parameters, chlorophyll-a concentration serves as a vital indicator of phytoplankton abundance, essential for accurately evaluating the eutrophication of a water body (Peppam et al. 2020; Liu et al. 2019). It serves as a significant indication of water quality and the biophysical condition of lakes (Liu et al. 2022). Consequently, the surveillance of chlorophyll-a content is quite significant. The conventional assessment of chlorophyll-a content in lake water primarily entails on-site sampling and subsequent laboratory testing and analysis, which are time-consuming, labor-intensive, and expensive. The study's conclusions lack universal applicability, and it is infeasible to acquire data on the spatial and temporal fluctuations of chlorophyll-a concentration on a wide scale (Guo et al. 2021). With advancements in remote sensing technology, the monitoring of lake water color exhibits rapidity, extensive coverage, and periodicity, effectively capturing the continuity, spatial dynamics, and regularity of changes in the aquatic environment. This approach addresses the limitations of conventional lake water quality assessments and facilitates the investigation of chlorophyll-a concentration distribution across expansive lake regions (Li et al. 2018). Therefore, the use of satellite remote sensing methods to observe variations in chlorophyll-a concentration has garnered significant interest.

At present, in the field of chlorophyll a concentration inversion research, scholars at home and abroad have achieved many results. Allan M G et al. (2011) conducted a comprehensive quantitative analysis of chlorophyll a concentration using Landsat enhanced thematic mapping (ETM) images. This study provides important reference value for the assessment of the spatiotemporal distribution of chlorophyll a concentration in the unmonitored areas of lakes in the central North Island of New Zealand. Rodriguez-Lopez et al. (2021) combined in-situ chlorophyll a concentration measurements with Landsat 8 satellite images to construct a set of linear and nonlinear models for estimating chlorophyll a concentration values in six Araukania lakes, which plays an extremely crucial role in the early warning of water environmental phenomena such as algal blooms. Barraza-Moragaf et al. (2022) constructed a multiple linear regression model by using the Sentinel-2 MSI sensor and obtained the spatial distribution of chlorophyll A concentration in Lake Lanalhue. Li Suju et al. (2002) established a remote sensing quantitative model of chlorophyll a by using the band ratio method and the first-order differential method, and studied the relationship between the spectral reflectance of Chaohu Lake water and chlorophyll concentration. The results showed that the band ratio method performed better in estimating the concentration of chlorophyll A. Ma Ronghua et al. (2005) used the correlation analysis method and combined with Landsat ET data M to conduct an inversion analysis of chlorophyll concentration in Taihu Lake. The analysis found that it was more appropriate to use 7×7 or 5×5 Windows for chlorophyll inversion. Li Yongliu et al. (2022) inverted the chlorophyll a concentration in Pingzhai Reservoir based on water body spectral data, measured chlorophyll a concentration and Sentinel-2 MSI remote sensing data. The results showed that the binomial function model of the band combination B8×(B7-B5) had a relatively high fitting accuracy. Meanwhile, the spatio-temporal variation law and influencing factors of chlorophyll a concentration in this area were comprehensively analyzed. Xiang Yabo et al. (2022) analyzed the correlation between the reflectance of each band of Landsat 8 data and the measured data of chlorophyll a in Shahu Lake. They found that the inversion model established in the fourth band had the best effect, with an average error of 7.28%. The above studies show that the optimal band combinations and inversion methods of chlorophyll a concentration inversion models corresponding to different research areas or even different sampling points in the same research area are not the same, and most of the above studies are aimed at some inland lakes. In the Qinghai-Tibet Plateau region, due to the influence of the harsh natural environment, large-scale on-site measurements of saltwater lakes on the plateau are rather difficult, which also restricts in-depth research in this aspect (Liu et al. 2017). At the same time, due to the lack of collection of a large amount of measured data and related parameters such as water body spectral data, The main methods adopted for constructing relevant water quality inversion models are generally relatively simple empirical statistical methods. Tao Xingyu et al. (2019) combined MODIS L1B data with the measured data of chlorophyll a concentration and found that the band reflectance ratio RB9/RB12 had the highest correlation, and the inversion effect of the univariate linear regression model was the best. They further explored the spatio-temporal distribution law of chlorophyll a concentration. Qinghai Lake is the largest inland saline lake in China and a crucial water supply for sustaining the ecological integrity of the northeastern Qinghai-Tibetan Plateau. The Environmental Quality Standard for Surface Water (GB 3838-2002) established by the Ministry of Ecology and Environment indicates that the integrated trophic state index (TLI index), utilizing chlorophyll-a as the primary parameter, demonstrates that the water body of Qinghai Lake is in a nutrient-deficient condition. In recent years, climate change, tourism development, and localized water contamination due to recurrent outbreaks of bristlecone algae have emerged as significant concerns (Hao et al. 2019). The aquatic ecosystem in the lake region has been seriously impacted. Developing a remote sensing inversion model for chlorophyll-a concentration in Qinghai Lake enables the analysis of long-term variations in chlorophyll-a levels and offers a comprehensive understanding of the lake's water quality, thereby serving as a reference for real-time monitoring of Qinghai Lake's ecological environment. This study focuses on Qinghai Lake, utilizing Landsat 8 remote sensing data from July 3, 2024, alongside measured chlorophyll-a concentration data from the same month. It develops an inversion model for chlorophyll-a concentration, conducts accuracy validation, and identifies the optimal model for inversion purposes. Meanwhile, utilizing the inverse model of chlorophyll-a concentration in Qinghai Lake, the spatial distribution characteristics of chlorophyll-a concentration in July 2024 were examined, offering a robust scientific foundation for enhanced monitoring of the nutrient status of Qinghai Lake's aquatic environment in subsequent phases.

2. Overview of the study area and data processing

2.1 Overview of the study area

Qinghai Lake (99°36′-100°46′E, 36°32′-37°15′N) is situated in the northeastern region of the Qinghai-Tibetan Plateau in China. It exemplifies the inland lakes and wetlands characteristic of this plateau globally and is the largest lake in China by area, serving as a crucial water source for the ecological security of the Qinghai-Tibetan Plateau. The largest inland saltwater lake in China receives water primarily from the Buha River, Quanji River, Shaliu River, Heima River, Inverted Flowing River, Hargei River, and Ganzi River, which are predominantly seasonal rivers (Chen al. 2013). In recent years, the aquatic ecosystem of Qinghai Lake has been affected to some degree by climate change and the swift expansion of tourism. Consequently, the ongoing assessment of water quality parameters in Qinghai Lake is crucial for the preservation of its aquatic environment (Qin et al. 1992).

2.2 Data collection and analysis

2.2.1 Data collection

Water samples were taken from July 1 to July 3, 2024, at 23 sampling locations in Qinghai Lake (Figur 1), ensuring uniform distribution around the lake to enhance the inversion effect during sampling. The latitude and longitude of each sampling location were documented on-site by GPS, and surface water samples were collected, cryopreserved, and dispatched to the laboratory for chlorophyll-A concentration analysis using spectrophotometry.

2.2.2 Determination of chlorophyll-a concentration

The water samples obtained from each site on the same day were pre-treated by utilizing a 47 mm diameter GF/F glass fiber filter membrane (pore size 0.45 μm to 0.7 μm) (Whatman, UK) within the filter unit, subsequently kept in a liquid nitrogen tank at low temperatures and shielded from light exposure. According to 'Determination of Chlorophyll-a in Water

Figure 1. Distribution of sampling sites in Qinghai Lake

Quality Spectrophotometer Method' (HJ 897-2017), algal cells filtered on a membrane are ground and crushed, followed by extraction of chlorophyll using a 90% acetone solution. Centrifugal separation is then performed, and the absorbance of the extract is measured in the laboratory using a UV spectrophotometer (T9CS, China) at wavelengths of 750 nm, 664 nm, 647 nm, and 630 nm, respectively. The concentration of chlorophyll-a in the water samples was determined using the equation.

2.2.3 Research method

This research utilizes Landsat 8 OLI time-series photos obtained on 3 July 2024, along with Landsat 8 OLI C2L2 multispectral images characterized by little cloud and air interference, which were downloaded and processed using ENVI 5.6 software. Utilizing the recorded chlorophyll-a concentration in Qinghai Lake from July 1 to 3, 2024, alongside the spectral data from the Landsat 8 remote sensing image at the same period. The Pearson correlation analysis of seven bands and chlorophyll-a concentration was conducted using Origin 2022 software, selecting the individual or combined bands with the highest correlation to construct an inversion model for determining chlorophyll-a concentration in Qinghai Lake. The chlorophyll-a concentration was ultimately approximated using the ideal model and compared with the measured values to validate the accuracy of the chlorophyll-a concentration inversion model.

3. Development of a chlorophyll-a inversion model

3.1 Analysis of the correlation between chlorophyll-a content and single-band reflectance

This study collected 23 sampling points, with the data utilized in a 2:1 ratio for the development and validation of the chlorophyll-a concentration inversion model (Zhang et al. 2019). Reflectance values for the different bands at each sampling location of Qinghai Lake were derived from Landsat 8 image data, and Pearson correlation studies were conducted between these values and chlorophyll-a concentration levels. The findings are presented in Table 1: The single-band B1, B6, and B7 bands had a substantial correlation with chlorophyll-a concentration, with correlation coefficients of 0.60, -0.63, and -0.68, respectively, while the B6 and B7 bands demonstrated a negative correlation with chlorophyll-a concentration. The B2 and B4 bands exhibited a modest correlation, with r values for 0.39 and 0.33, respectively; the B3 and B5 bands demonstrated a very weak correlation with chlorophyll-a content. Qinghai Lake, being an inland saline lake, possesses a significant concentration of metal ions and considerable interference, rendering the construction of a chlorophyll-a concentration inversion model using a single band less effective (Tao et al. 2019).

Table 1. Correlation Analysis of Chlorophyll-a Concentration and Single Band Reflectance

wave band	B1	B2	B3	B4	B5	B6	B7
Chlorophyll-a concentration	0.60	0.39	-0.0087	0.33	-0.03	-0.63	-0.68

Note: Pearson's correlation coefficient (r), $0 < |r| < 0.2$ very weak correlation or no correlation, $0.2 < |r| < 0.4$ weak correlation, $0.4 < |r| < 0.6$ moderate correlation, $0.6 < |r| < 0.8$ strong correlation, $0.8 < |r| < 1.0$ very strong correlation, $r > 0$ indicates positive correlation and $r < 0$ indicates negative correlation.

3.2 Correlation between chlorophyll-a concentration and band combinations along with their changes

The bands responsive to chlorophyll-a concentration were subsequently chosen for band combinations utilizing ratio, product, summation, and difference, and were tested for Pearson correlation with chlorophyll-a concentration.

Table 2 shows the results of the correlation analysis between different band combining techniques and chlorophyll-a concentration. The findings indicate: Among the 13 distinct band combinations, combination B6-B7 exhibited the highest correlation, demonstrating a robust correlation with chlorophyll-a concentration, characterized by a correlation coefficient r of 0.79, and an exceptionally strong correlation with the natural logarithmic transformation of chlorophyll-a concentration, indicated by a correlation coefficient r of 0.85. Furthermore, it was determined that the modeling efficacy was superior in the combination of band combinations compared to individual bands.

Table 2. Correlation Analysis of Chlorophyll-a Concentration and Band Combinations

wave portfolio	Chlorophyll a concentration	Natural logarithm of chlorophyll-a concentration
B1+B5	0.60	0.70
B1+B6	0.53	0.62
B1+B7	0.47	0.56
B5+B6	-0.63	-0.76
B5+B7	-0.68	-0.80
B6+B7	-0.66	-0.78
B1-B5	0.60	0.70
B1-B6	0.62	0.74
B1-B7	0.64	0.75
B5-B6	0.63	0.76
B5-B7	0.68	0.80
B6-B7	0.79	0.85
B6*B7	-0.63	-0.78

Note: Pearson's correlation coefficient (r), $0 < |r| < 0.2$ very weak correlation or no correlation, $0.2 < |r| < 0.4$ weak correlation, $0.4 < |r| < 0.6$ moderate correlation, $0.6 < |r| < 0.8$ strong correlation, $0.8 < |r| < 1.0$ very strong correlation, $r > 0$ indicates positive correlation and $r < 0$ indicates negative correlation.

4. Results and Discussion

4.1 Modeling of Chlorophyll-a Concentration

Presently, the inversion of chlorophyll-a concentration typically involves selecting bands or combinations of bands that exhibit heightened sensitivity to chlorophyll-a concentration for model development (Sun et al. 2019). The study revealed that fitting linear, polynomial, exponential, hyperbolic, and logarithmic functions using multiband combinations resulted in improved inversion of chlorophyll-a concentration and its natural logarithm. Therefore, the multi-band combination B6-B7, which has a strong correlation with chlorophyll-a concentration, was selected to mimic the inversion in this investigation. The results presented in Table 3 indicate that the coefficients of determination (R^2) for the inverse models were all below 0.7 when chlorophyll-a concentration served as the dependent variable. When the natural logarithm of chlorophyll-a concentration served as the dependent variable, the coefficients of determination (R^2) for the inversion models exceeded 0.7, indicating superior inversion performance, with the linear function inversion achieving the highest R^2 of 0.7017.

Table 3. Inversion outcomes of chlorophyll-a concentration and band amalgamation

Implicit variable	Independent variable	Fitting method	Fit a model (math.)	R^2
Chlorophyll-a concentration	B6-B7	Linear	$y = 211.2994x + 0.5715$	0.6104
		Exponential	$y = 211.4800\exp(x) - 210.9085$	0.6104
		Hyperbolic	$y = 1/(1.7881 - 910.5231x)$	0.5590
Natural logarithm of chlorophyll-a concentration	B6-B7	Linear	$y = 607.3806x - 0.5380$	0.7017
		Exponential	$y = 607.8302\exp(x) - 608.3682$	0.7016

4.2 Assessment of the accuracy of the chlorophyll-a concentration model

In the context of model validation utilizing measured data not incorporated in modeling, data from eight sampling sites were randomly allocated as validation data for model correctness at a 2:1 ratio due to the limited number of sampling points in this study. To extensively assess the model's accuracy, particular emphasis is placed on the primary metric of root mean square error (RMSE), which indicates the extent of divergence between the model's predicted values and the actual observed values; a smaller RMSE signifies greater stability and reliability of the model (Bao et al. 2024). Figure 2 displays the fitted scatter plot. The findings indicated that the chlorophyll-a concentration inversion model achieved a r value of 0.61199, a root mean square error (RMSE) of 0.162 μg/L, and a mean absolute error (MAE) of 14.36%, demonstrating commendable accuracy (Li et al. 2024; Li et al. 2020).

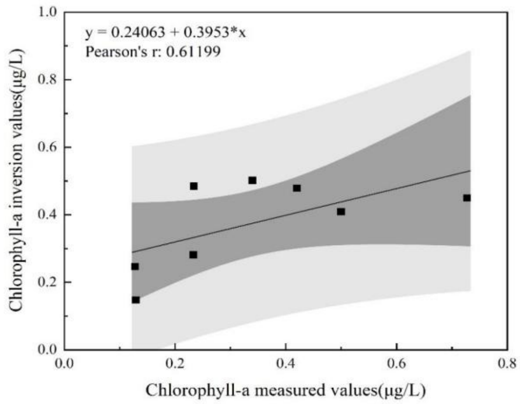

Figure 2. Scatterplot of modelling and validation data fit

4.3 Chlorophyll-a concentration inversion results of Qinghai Lake

The inverse distribution map of chlorophyll-a concentration in Qinghai Lake was derived by applying the developed chlorophyll-a inversion model to Landsat 8 remote sensing data, as illustrated in Figure 3. The map approximately illustrates the regional distribution of chlorophyll-a concentration in Qinghai Lake, showcasing the efficacy of Landsat 8 imagery for inverting chlorophyll-a content in highland brackish water lakes. The figure illustrates that chlorophyll-a concentration is elevated at the mouths of the Heima River, Bird Island, and near Erlangjian, while it is diminished at the mouths of lakes such as the Buha River and the Shaliu River, potentially attributable to the effects of runoff and other hydrodynamic factors at these locations. The lowest chlorophyll-a content was observed in the Shaliu River according to Chen Xuemin et al. (2013). In the research conducted by Miao Shiyu et al (2019), chlorophyll-a concentration was recorded as low (<0.7 μg/L) in the shallow waters at the Buha River mouth and the northern section of the lake area, with an average chlorophyll-a concentration of 0.8 μg/L. The current study reported a mean chlorophyll-a concentration of 0.5 μg/L.

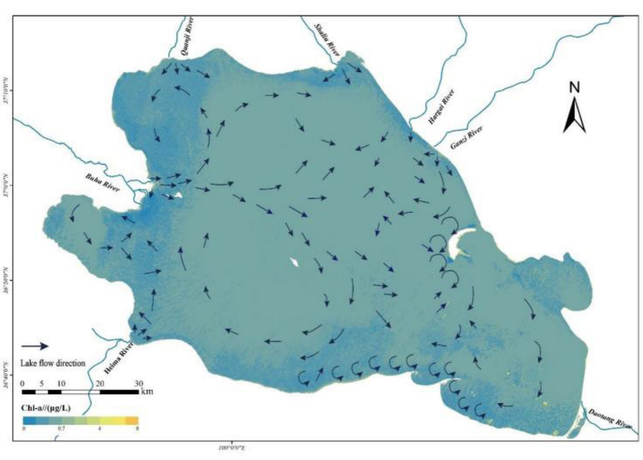

Figure 3. illustrates the hydrodynamic properties of Qinghai Lake and the inverse distribution of chlorophyll-a concentration in July 2024.

4.4 Discussion

In this study, the selection of the most sensitive band using Pearson's correlation coefficient revealed a strong correlation between chlorophyll-a concentration and the single bands B1, B6, and B7, with the highest correlation of -0.68 in band B7, indicating a significant deviation from the typical spectral curve. This study concluded that differences in study areas, selection of sample locations, and the volume of valid measured data would influence the inversion results. Other scientists have observed that varying concentrations of chlorophyll-a exhibit greater absorption at wavelengths of 400-500 nm and 675 nm (Shu et al. 2000). Prominent reflection peaks are observed at wavelengths of 550 nm and 700 nm (Sun et al. 2013), which exhibited low correlation when the most highly correlated bands were chosen for this investigation (Zhong et al. 2017). Therefore, when developing the inversion model, it is essential to include the various aquatic conditions in the study area, along with the impact of sample data influenced by factors such as variable wind speed and illumination. The chlorophyll-a distribution map for Qinghai Lake (Figure 3) illustrates significant geographical spatial variations in chlorophyll-a concentration. Notably, elevated concentrations are observed near the Heima River mouth, Bird Island, and Erlangjian, while diminished concentrations are found at the mouths of the Buha River, Shaliu River, and other inflowing rivers. This may result from a number of causes, including inputs from terrestrial sources, lake hydrodynamic processes, and topography and geomorphology (Zhang et al. 2024). Much study has been conducted on the hydrodynamic dynamics and geography of Qinghai Lake (Cong 2021). The hydrodynamic conditions and intensity across various regions of Qinghai Lake are heterogeneous. The Buha River, flowing from west to east, generates the primary circulation, which alters around Haixinshan within the lake area. This results in the formation of two significant main circulations on the southern and northern flanks of the Buha River's inlet, while secondary circulations emerge near Shadao Island. Additionally, smaller circulations are present near Erlangjian due to the substantial impact of winds and waves, alongside the intricate characteristics of the lake's currents (Yuan et al. 2016). This study found that chlorophyll-a concentration was elevated around the Heima River inlet, Bird Island, and Erlangjian of Qinghai Lake; this distribution aligns closely with the primary circulation patterns and the hydrostatic zones of the lake and bay backwaters. The lake bay reflux area is primarily constrained by the semi-enclosed topography, which impedes fluid movement. Consequently, the hydrodynamics in this region are typically subdued, leading to stagnant lake conditions. This stagnation often results in the accumulation of floating algae at the reflux center, thereby influencing the concentration of chlorophyll-a. The primary reflux areas of Qinghai Lake are the Heimahe Lake Bay reflux area and the southeastern lake bay reflux area, among others. The inversion map of this study (Figure 3) indicates elevated chlorophyll-a concentrations in these two places, demonstrating the alignment between the inversion results with the dynamic characteristics of Qinghai Lake's hydrodynamics. Li Shutong et al. (2018) discovered that hydrodynamic characteristics govern sediment movement in their investigation of lake dynamics, with silt accumulation primarily occurring in Shadao Island, the eastern side of Erlangjian, and the vicinity of Jiangxi Gorge, among other locations. This supports the findings of the current investigation and indicates that lake hydrodynamics significantly affects the regional distribution of chlorophyll-a concentration. The work by Zhang Qin et al. (2024) similarly indicated that the structure and velocity of the oceanic flow field influence the transport and distribution of nutrients in the water column, hence affecting chlorophyll-a concentration. Furthermore, the concentration of chlorophyll-a was diminished at the lake inlet estuaries, including Buha River and Shaliu River, according to the inversion results of this study. This finding aligns with the research conducted by Wang Lingling et al. (2009) which established a correlation between water flow rate and chlorophyll-a concentration in Kuwana Bay, indicating that an increase in water flow rate corresponded with a decrease in chlorophyll-a concentration. This suggests that alterations in hydrodynamic conditions significantly impact chlorophyll-a concentration in Kuwana Bay. The research conducted by Zhang Yimin et al. (2007) revealed that hydrodynamic factors significantly influence algal growth, with wind altering hydrodynamic conditions, thereby impacting algal growth and aggregation, which subsequently affects chlorophyll-a concentration in the water column. The aforementioned data demonstrate that the inversion outcomes of chlorophyll-a concentration in this investigation are viable. In conclusion, our findings indicate that chlorophyll -a is influenced not only by light and many elements in the lake region but also by lake hydrodynamics, corroborating the results of Zhou Luhong et al. (2012), Li Shuangzhao et al. (2017), Li Feipeng et al. (2013), and others. Spatial variations in hydrodynamic conditions influence chlorophyll distribution, and in the ensuing chlorophyll inversion analysis, it is pertinent to account for light, nutrient salts, water temperature, and other contributing factors, as well as the effects of lake hydrodynamic variables.

5. Conclusions and Applications

This paper developed an inversion model for chlorophyll-a concentration in Qinghai Lake utilizing data from the Landsat 8 multispectral remote sensing satellite, incorporating 23 sampling points and measured data, and produced a spatial distribution map of chlorophyll-a concentration in Qinghai Lake, leading to the following conclusions:

(1) The Pearson correlation study of band reflectance and chlorophyll-a concentration from Landsat 8 remote sensing imagery indicated a strong link between the reflectance of bands B1, B6, and B7 and the chlorophyll-a concentration in Qinghai Lake. Further combinations of the various bands indicated that band combination B6-B7 exhibited a strong correlation with the natural logarithm of chlorophyll-a concentration, with an r value of 0.85.

(2) The chlorophyll-a concentration served as the dependent variable, while the optimal band combination B6-B7 functioned as the independent variable. An inversion model was developed utilizing linear, exponential, logarithmic, and hyperbolic functions. The linear regression model demonstrated the most effective inversion, with an R^2 value of 0.7017 for the chlorophyll-a concentration model $y = 607.3806x - 0.5380$. This model exhibited superior accuracy and could serve as a foundation for remote sensing of chlorophyll-a concentration in similar inland water bodies. This technology can serve as a foundation for the remote detection of chlorophyll-a concentration in similar inland water bodies.

(3) The distribution characteristics of chlorophyll-a concentration in Qinghai Lake in July 2024 were examined using the optimal inversion model. The findings indicated that chlorophyll-a concentrations were lower at the mouths of the Buha and Shaliu rivers and higher at the mouths of the Heima River, the Erlangjian coast, Bird Island. This change results of a combination of factors including nutrient input, hydrodynamic processes of the lake, and water temperature, among others. The distribution characteristics align with the hydrodynamic features of Qinghai Lake to a degree, thereby validating the feasibility of this inversion's results.

(4) The distinctive aquatic ecosystem of Qinghai Lake leads to a complex and varied water composition, causing instability in the functional relationship between wave reflectance and chlorophyll-a concentration, thereby incurring substantial research expenses in the development of the inversion model. Moreover, the empirical analysis method selected in this study for model construction is devoid of a physical foundation and possesses certain limitations; thus, alternative methods such as the BP neural network model and multiple linear regression model should be incorporated in future research to enhance the accuracy of the chlorophyll-a concentration inversion model for Qinghai Lake.

In summary, this study provides effective methods and technical support for the remote sensing inversion of chlorophyll-a concentration in Plateau saltwater lakes, offering new ideas for the research and practice of water environment monitoring and health assessment of plateau saltwater lakes. Meanwhile, the special geographical location of Lake Qinghai, combined with climatic factors and human activities, can help to further understand the distribution and change process of chlorophyll-a concentration in Qinghai Lake, which is of great significance for continuing to carry out lake ecological protection and promoting the healthy management of ecological environment in Qinghai Lake Basin.

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Article Highlights

The remote sensing satellite inversion technology is applied to the inversion of water quality parameters of plateau lakes, so as to monitor the health status of plateau lakes, formulate relevant lake health management strategies more efficiently, and better protect the ecological environment of lake water.

Availability of data and materials

The authors declare that the data supporting the findings of this study are available within the article.

Competing interests

The authors declare no competing interests.

Authors' contributions

Shi Jing: Conducting experiments, investigations, analysis, data collection and collation, making frameworks, researching ideas, and writing first drafts. Niu Hailin: Supervision, Foundation, Experimental Guidance, Methodology, Manuscript Proofreading. Xie zhaoyang: Data management, validation, visualization.