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ABSTRACT: This paper selects lake and river areas in Jinjiang City as the study objects. Eutrophication and dynamic change of water bodies are monitored via field fixed-point monitoring, according to different temporal and spatial monitoring data of a decade, using multi-temporal remote sensing image data processing technology and computer simulation method based on comprehensive nutrition index method. The monitoring results have shown that since 2006, Jinjiang water body has been at a mild eutrophication level, and with the passage of time, the overall situation had risen first and decreased afterwards from January to December. The establishment of corresponding water environment ecological monitoring protection and early warning mechanism is put forward to improve the ability of water quality monitoring according to the results of the dynamic monitoring.

Keywords: remote sensing technology; water eutrophication; satellite image; dynamic monitoring; ecological civilization construction

Ecological civilization construction is the inevitable choice of social development. Practice shows that the traditional economic development model does not adapt to the sustainable development of the future society any more, the traditional development model has brought many negative impacts to different regions, of which ecological crisis is the most significant one, air pollution, water pollution, surface collapse, water loss and soil erosion, noise pollution, severely exceeded PM2.5 standards and other phenomena have seriously affected the survival of mankind. Relevant data show that water eutrophication degree (medium nutritious level and eutrophication degree) of lakes and reservoirs has risen to 77% and 83%. In general, the development trend of China’s water quality eutrophication is very serious[1]. Therefore, to strengthen water monitoring, especially the dynamic monitoring of water source eutrophication of residents living water in the future is particularly important.

In the past, water quality changes were measured via conventional methods, which would consume a great deal of financial and material resources and manpower, and data processing and analysis effects were not obvious. Later in order to solve the problem, researchers carry out continuous explorations and trials aiming at the diversity, dynamic nature, periodicity and timeliness of information, and then remote sensing science is developed. Water quality changes within the region are dynamically monitored through remote sensing technology, and the effects are excellent. Currently, typical application researches on remote sensing technology are Schmidt, Aprakash, etc., carrying out monitoring and evaluation[2,3] on environmental changes; Wang Baocun, Yang Shengjun and other researchers monitor water changes (using CBETS, MSS, QUICBIRD, TM/ETM data)[4,5]. In this paper, we use comprehensive nutrition index method, combining with satellite and TM/ETM + data, carry out multiple temporal and spatial dynamic monitoring (varying data of 10 years), and make corresponding assessment on the development trend of Jinjiang City water body water quality eutrophication.

1 OVERVIEW OF STUDY AREA

Jinjiang City is located in the central and southern part of Fujian Province, with subtropical semi-humid climate, mainly with hills, terraces and plain landscapes, with many harbors. In the research area, there are many river systems with large density. The overall basin area of river systems is 5629 km², the total length of the main channel is 182 km, and the average annual runoff volume is 4.88 billion m³. Longhu Lake
and Huihu Lake are the largest and the third largest natural freshwater lake in Fujian Province, with the catchment area of 45.6 km$^2$, the lake area of 2.69 km$^2$ and total storage capacity of 6.1 million m$^3$ (See Figure 1). Jinjiang economic industry is mainly composed of traditional manufacturing, and the development momentum is strong. Because of the unrestricted development of early manufacturing, the local resources are extremely scarce nowadays, natural ecological destruction is more obvious, especially, the destruction of local water resources is more apparent due to leather, stone, shoes, clothing, textiles and other manufacturing industries. Therefore, to strengthen the dynamic monitoring of water ecology eutrophication has the vital significance to the management and development of Jinjiang City water ecological environment.

![Figure 1. Basic information of lake and river areas in Jinjiang City.](image)

2 DATA SELECTION AND IMAGE PROCESSING

Data in the study of this paper is from relevant materials of Jinjiang City Environmental Protection Bureau, such as the experiment testing data of water sample and the remote sensing data (different satellite remote sensing data of 8 periods from 2006 to 2015, Table 1). The analysis data of water sample experiment and detection comes from the water sampling test data within the study city areas on Oct. 20, 2015. Since there are many tested and detected items, several items having large relevance with water eutrophication shall be listed out herein, including phosphorus content (P), Clarity, Chlorophyll, KMnO$_4$, nitrogen (N) and other indexes, see Table 2 for details (the top 20 sets of data is used to construct the index evaluation model below, and the rest 10 sets of data is used in model tests).

![Table 1. Main parameters of remote sensing image.](image)

![Table 2. Laboratory tested data of water samples.](image)

3 DYNAMIC MONITORING OF WATER ENVIRONMENT IN RESEARCH AREAS

3.1 Multiple temporal and spatial variation of hydrology in land development and utilization

Land exploitation and utilization of Jinjiang City are mainly used for industrial construction, business de-
development, agricultural land, etc. Supervised classification shall be carried out on satellite remote sensing images in 2006, 2008, 2009, 2012, 2013, 2014 and 2015 according to the principle of maximum likelihood classification method, after field researches, land exploitation and utilization of research areas are divided into urban land, rural land, other land, farmland, water area, mountain, etc. according to the objective facts (See Figure 2).

From Figure 2, it is clear that change in 10-year land spatio-temporal utilization from 2006 to 2015 is very obvious. It expands very quickly mainly from urban construction land and rural construction land, especially, industrial land has increased greatly, farmland and greenbelt area have reduced rapidly, and hydrological ecology has changed significantly. According to relevant statistics, it shows that farmland area has reduced more than 20%, and industrial and commercial land areas have increased more than 40% [6] in Jinjiang from 2006 to 2015.

3.2 Evaluation model description of eutrophication of water environment and ecology

In the study, TLI evaluation models for P, clarity, chlorophyll, KMnO₄, N and other indexes (established according to TLIC[7]) are established by analyzing testing data of water sample through using satellite data influence and remote sensing technology, which can obtain ecological spatial and temporal distribution of water areas easier than traditional tested water samples. Logarithm (ln) of 5 indexes and error conditions (Table 3) in 2015 can be calculated based on the data in Table 2 by using SPSS.

According to the TLI evaluation model principle for comprehensive nutrition index building and 10 groups of test data of water sample tests, TLI models of all indexes can be obtained:

1. TLI(P)=10*(9.53+1.65ln)
2. TLI(Clarity)=10*(5.45-2.11ln)
3. TLI(Chlorophyll)=10*(2.7+1.36ln)
4. TLI(KMnO₄)=10*(0.16+2.84ln)
5. TLI(N)=10*(5.66+1.81ln)

According to TLI evaluation indexes and water eutrophication and ecology, from Figure 3, it is clear that the changes in spatio-temporal utilization of ecological eutrophication of Jinjiang water environment.
trophication standards, it is divided into 5 evaluation standards from high to low, i.e. eutropher (70-100), middle eutropher (60-70), light eutropher (50-60), mesotropher (30-50), oligotropher (0-30).

According to the obtained calculation formula of 5 TLI models, eutrophication degree of Jinjiang water environmental quality in 2015 can be calculated. Then the model formula is applied into 2 wave bands (images of Satellite 1) in 2012, the eutrophication variation degree of Jinjiang water during different periods can be calculated by using comprehensive nutrition index algorithm (Figure 3).

From Figure 3(1), it can be seen that due to the non-environmental protection operations of manufacturing enterprises, especially the indiscriminate discharge of industrial wastewater, discharge of agricultural pollution sources, etc., Jinjiang hydrological environment belongs to a mild degree of eutrophication as a whole. But seeing locally, the degree of eutrophication of southeast and southwest is much higher than the middle, which is consistent with the field observation of water samples. Major reasons for such results are related to the manufacturing enterprises and the unscientific processing of resident aquaculture feed in these places.

By calculating the image data of Satellite 1 (SHJ01) in August, 2012 and November 2012 according to TLI model calculation formula, the result shows that water quality eutrophication degree changes as the time changes, the test result of August is moderate eutrophication degree, while it is mesotropher in November. It is to say that the water quality eutrophication degree of Jinjiang is in a change state that rises first and falls later as time goes on.

4 DISCUSS

Water quality index of Jinjiang water ecological environment is changing with the development of economy, and the eutrophication degree of water quality will also increase, especially the unreasonable and unscientific use of land spaces and natural resources will cause extremely far-reaching impacts on drainage structure and water quality.

In this paper, water environment change of Jinjiang City is dynamically monitored by using satellite remote sensing technology, the water quality index can be evaluated more rapidly and accurately, and the measurement range is wider than traditional method, the evaluation results of measurement are also more satisfied. However, some disadvantages can also be found from the experimental operation process, especially that the precision analysis on models shall be further improved. For the whole experiment process, it is necessary to add the sample number of field measurement, improve the accuracy of results, and consider the increase of the specific evaluation measurement method of aquatic organisms (optical image method, spectrum measurement method for water materials, etc.), and the application scope of evaluation model test can be effectively expanded in this way.

5 CONCLUSION AND COUNTERMEASURES

This study tests the change situation of water quality eutrophication degree of Jinjiang water environment by using satellite remote sensing image data technology, combining with the related test analysis methods for 30 water samples selected on field. Results show that during these 10 years, land cover and space use structure of the researched areas had changed dramatically along with the scale expansion of manufacturing enterprises, production of new enterprises, unreasonable discharge of agricultural pollution sources and other phenomena in Jinjiang, especially that the ecological impacts on water environment in the researched areas are great, which mainly caused the aquatic organisms dead from oxidant, cadmium, copper, acid, ethylene glycol, alkali and large amounts of toxins in water body, and the quality of water source is seriously affected; decomposition of organic matter in pollutant has to greatly deplete oxygen molecules in water, causing the anaerobic decomposition of organic matter in water, a large number of hydrogen sulfide, mercaptan and other odor gases generated after decomposition will make water quality worse. These phenomena have caused serious influences on water environment of the researched areas, and the monitoring results show that the monitored water quality in Jinjiang has reached the eutrophication degree, the overall index is of a mild eutrophication level. Therefore, dynamic monitoring and management of water environment in the construction of water ecological environment is imminent, the countermeasures are basically as follows:

1. Greatly develop dynamic on-line monitoring of water environment, and improve monitoring ability. Summarize the past practical experience, develop new on-line water environment monitoring system software, and nationally promote the developed CEMS system (continuous monitoring system for discharge of flue gas, waste water and other pollutants) after achieved substantive breakthrough in technology;

2. Establish an effective ecological monitoring mechanism of water environment. Ecological monitoring of water environment has overcome the most of defects in physical and chemical monitoring, which can comprehensively reflect the objective water quality condition compared to physical and chemical monitoring, and is with multi-function, sensitivity and other characteristics of continuous monitoring;

3. Use satellite remote sensing technology to monitor the dynamic change of water environment in a wider range. Remote sensing technology has wider range, dynamic, continuous monitoring, forecast and other functions, which can provide a basis for water
environment pollution treatment.

Water pollution is a serious threat to the healthy development of human society. Therefore, we must always strengthen working force on monitoring of water environment. At present, the water environment monitoring work in China exist monitoring technology backwardness, indifference to monitoring work and other factors, it is caused that water environment in China deteriorates rapidly nowadays. Therefore, we must draw lessons from history, and greatly promote on-line monitoring system, excellent ecological monitoring mechanism, satellite remote sensing monitoring and other efficient monitoring technologies to improve the work timeliness of water environment dynamic monitoring in China.

REFERENCES


