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Study on the Water Quality and Protection Measures of Dongting Lake

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Abstract From nitrogen and phosphorus, chemical oxygen demand, phytoplankton, and eutrophication, this article analyzes the current situation of water quality in the Dongting Lake area, and discusses the factors influencing the water quality of Dongting Lake. Based on the actual production, geographic characteristics and outstanding problem of grim water pollution situation in the Dongting Lake area, some specific proposed measures are put forward in order to provide the basis and reference for the future pollution control in the Dongting Lake area, such as strengthening the industrial pollution control, developing ecological agriculture, and enhancing ecological restoration and water quality early warning.

Key words Dongting Lake, Water pollution, Current situation, Prevention measures

Dongting Lake is a flood basin of the Yangtze River, and it is also fed by four major rivers: the Xiang, Zi, Yuan and Li rivers. It plays an important role in the ecology and economy of Hunan Province and the Yangtze River Basin. The Dongting Lake area is a major light industrial base in Hunan Province, so there is more wastewater generated [1]. Over the past decade, the water quality of Dongting Lake has basically remained at Ⅳ or Ⅴ class, in the mesotrophic state or mild eutrophication state. The main pollution indicators are total phosphorus, or total nitrogen. The pollution type has been changed from the previous industrial pollution to diversified pollution [2], and since 2003, the proportion of industrial pollution has declined, while the agricultural nonpoint source pollution and urban domestic pollution have increased [3].

1 The current situation of water quality

The water pollution of Dongting Lake is mainly the nitrogen and phosphorus pollution. The water body condition is gradually deteriorating and the degree of eutrophication is aggravated year by year [4-6].

1.1 Changes of nitrogen and phosphorus In recent years, the main pollutants in the water body of Dongting Lake are total nitrogen and total phosphorus, and the water pollution is serious.

Total nitrogen is the nitrogen content of all compounds containing nitrogen in the water body. Total nitrogen mainly reflects the degree of contamination of water, and the increasing nitrogen content in water will result in declining water quality. The annual average total nitrogen content of Dongting Lake water is 1.25 mg/L, and except for 1998, the total nitrogen content of water exceeds water quality standard Ⅲ of surface water.

Total phosphorus is the total amount of phosphorus of various forms in water, and is one of the important indicators reflecting the degree of eutrophication lakes and reservoirs and the degree of water contamination. The increasing phosphorus content of water body will lead to water quality degradation, and mass propagation of the plankton and algae in the water, thereby consuming the dissolved oxygen in the water, and accelerating eutrophication of water body of lakes and reservoirs.

The annual average total phosphorus content of Dongting Lake water is 0.07 mg/L, and since 2000, the total phosphorus content has significantly risen (0.08 - 0.13 mg/L), exceeding water quality standard Ⅲ of lakes, and in some years exceeding water quality standard Ⅳ.

1.2 Chemical oxygen demand The chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water (*e. g.* lakes and rivers) or wastewater, making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L) also referred to as ppm (parts per million), which indicates the mass of oxygen consumed per liter of solution.

The annual average chemical oxygen demand of Dongting Lake water is 4.39 mg/L. The lowest value was 2.23 mg/L in 1991 while the highest value was 8.2 mg/L in 2002. In the early 1990s, the chemical oxygen demand of Dongting Lake water was very low; after 1997, the chemical oxygen demand began to rise; in 2002, there was a slight decline after reaching a peak, but it still remained at a high level [7].

1.3 Phytoplankton The number of phytoplankton in Dongting Lake shows an overall upward trend. For many years, there is no significant difference in the number of phytoplankton between the

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lake regions.

In the period 2007 – 2008, the number of phytoplankton grew rapidly in East Dongting Lake, and in 2008, the number of phytoplankton in the center of East Dongting Lake was up to 13.7×10^5 L^{-1}, and there was mild eutrophication. With the increase in the number of phytoplankton in the lake, the biomass was significantly reduced in the lake in the period 2009 – 2011 [3]. From 2006 to 2010, the number of phytoplankton in Dongting Lake showed an overall upward trend.

Since 2006, Cryptophyta in many monitoring sections has become the dominant species in Dongting Lake, indicating that the water quality of Dongting Lake has markedly deteriorated, which is consistent with the chemical indicators of waters [3].

The number distribution of phytoplankton, and community structure are closely related to environmental conditions of lakes, and can be used as the bio-indicator of water pollution.

Dongting Lake has long been at the medium level of eutrophication [8], making the number of plankton and biomass smaller than that of other large and medium-sized lakes in the middle and lower reaches of Yangtze River [9].

1.4 Eutrophication Previously Dongting Lake was always at the medium level of eutrophication, and the main reason was that before the construction of the Three Gorges Project, it was a water-carrying lake characterized by large annual runoff volume, high lake sediment concentration and short period of water cycle, to a certain extent inhibiting the eutrophication development [10].

After the running of the Three Gorges Project, the lake water and sediment were reduced [11 – 13], and the transparency of the lake was increased; the period of water cycle was increased, the water environment was relatively stable, and the lake water environment capacity was reduced [14], promoting the eutrophication of Dongting Lake [3].

In recent years, Dongting Lake has long been at the medium level of eutrophication, but ∑TLI of the whole lake shows an upward trend overall. ΣTLI of East Dongting Lake tends to rise, and in the period 2008 – 2010, ∑TLI exceeded 50, showing mild eutrophication [3].

Over the past 10 years, ΣTLI of South Dongting Lake and West Dongting Lake has fluctuated around 40 to 50, with medium level eutrophication water body. ΣTLI of East Dongting Lake is higher than that of South Dongting Lake and West Dongting Lake [15].

2 The factors influencing the water quality of Dongting Lake

The factors influencing the water quality of Dongting Lake include industrial pollution, urban domestic pollution and agricultural non-point source pollution [16]. And the non-point source pollution is the main source of excess N and P in Dongting Lake.

2.1 Industrial pollution Industrial pollution is a major factor leading to changes in the water environment of Dongting Lake. The industrial wastewater from the upper reaches of Yangtze River and the polluting enterprises around the lake form the main sources of pollution in Dongting Lake.

From the late 1980s to the early 1990s, a large number of polluting enterprises clustered in the lake area, resulting in decreased water quality and sharp ecosystem function decline.

According to the survey, 362 million t of wastewater is discharged annually in the lake area, and the heavy metal contained in the wastewater is the main source of pollution in Dongting Lake area.

2.2 Agricultural pollution Agricultural non-point source pollution is the most important and most widely distributed non-point source pollution. The agricultural pollution in Dongting Lake wetland mainly includes the fertilizer pollution, pesticide pollution, aquaculture and livestock manure pollution.

2.2.1 Pesticide and chemical fertilizer pollution. Excessive application of chemical fertilizer, irrational application mode and neglecting organic fertilizer, are the main reasons for non-point source pollution in the Dongting Lake area. The utilization rate of fertilizer in the paddy field is low in the southern regions of China, and the remaining nutrients enter into the environment through a variety of ways.

In the Dongting Lake area, the amount of total nitrogen flowing into the water is up to more than 2 700 t due to the application of chemical fertilizer annually [5]. After the excessive chemical fertilizer enters into water, the algae grow and reproduce rapidly, which consumes a lot of dissolved oxygen, resulting in the loss of ecological functions of water.

In addition, because of the unreasonable and excessive use of pesticides, the environment has been seriously polluted.

2.2.2 Aquaculture pollution. The Dongting Lake area is an important freshwater aquaculture base in China. According to statistics, the aquaculture area of the 8 regions in the lake area was 116000 hm2 in 2007.

The aquaculture in the Dongting Lake area has the following characteristics: (i) The feed input is high; (ii) There is considerable input of chemical fertilizer; (iii) Drugs, such as insecticides and fungicides, are extensively used.

The drug application has broken the original ecosystem balance, causing biological and environmental changes, such as dwindling water plants and zooplankton, and water quality deterioration. In addition, the fish feces and rotting debris also accelerate the pollution of water body [17].

In recent years, the poultry and livestock breeding industry has developed rapidly in the Dongting Lake area, and the total amount of wastewater reaches 18.1 t. The feces from the breeding industry will finally enter into Dongting Lake via the river. Relative to the industrial pollution source control, the ability to control the environmental pollution caused by poultry and livestock breeding in rural areas is still quite weak.

2.3 Domestic pollution The domestic pollution in the Dongting Lake wetland is mainly caused by the domestic sewage from kitchen, toilets and garbage.

The total annual emission of urban domestic sewage is about 1 billion t in Hunan Province, the amount of COD generated is about 400 000 t, and the amount of ammonia and nitrogen is about 35 000 t. The province's urban sewage treatment rate is 8.47%, and the vast majority of sewage is discharged into Dongting Lake.

It is calculated that the daily amount of domestic sewage in the Xiang River valley flowing into Dongting Lake is as high as 610000 t, equivalent to 48.8t of pure nitrogen and 1.8 t of pure phosphorus, constituting the major source of pollution in Dongting Lake wetland [6].

3 Protection measures and recommendations

Wetland has the decontamination function, and it is hailed as "nature's kidney". If the emissions exceed its capacity, it will inevitably have a negative impact on the structure and function of wetland systems, cause serious pollution to the wetland ecosystems, and make the ecological functions severely degrade.

Therefore, it is necessary to strengthen the construction and protection of Dongting Lake.

3.1 Strengthening the industrial pollution control and accelerating the urban sewage treatment Firstly, there is a need to increase industrial restructuring, and strengthen industrial pollution control; increase investment in environmental protection, strengthen governance of major polluting industries, and encourage the development of non-polluting industries with technological content to reduce pollution at the source.

Secondly, it is necessary to accelerate the development of circular economy and promote clean production; promote the recycling use of industrial water and develop water-saving industry.

Thirdly, the sewage treatment plant in the Dongting Lake area should have the supporting nitrogen and phosphorus removal facilities [7].

3.2 Developing ecological agriculture and strengthening the comprehensive control of agricultural non-point source pollution The Dongting Lake area should take actions that suit local circumstances to carry out rural sewage and garbage pollution control, and build sewage treatment facilities; build ecological farms, pay close attention to the transformation of large-scale livestock farms, and strengthen the management of discharge water for breeding industry [7].

3.2.1 Rational fertilization and pesticide application. It is necessary to vigorously promote the use of soil testing and formula fertilization technology, accelerate the pace of using compound fertilizer to replace the chemical fertilizer with single nutrient, and increase the application of some special fertilizers [18]; increase the application of bio-organic fertilizer, expand application area, and improve the water and fertilizer retention capacity of soil to reduce the non-point source pollution of chemical fertilizer; scientifically use pesticides and vigorously promote the use of bio-pesticides; promote integrated pest control, strengthen the prediction of plant diseases and insect pests, and try to use the readily biodegradable efficient pesticides to reduce pesticide pollution to the environment and agricultural products [19].

3.2.2 Water recycling. The recycling of wastewater can make us use the natural resources to the extreme under the existing conditions.

China's agricultural water use amount accounts for more than two thirds of the national total water use amount, so developing agricultural water recycling technology is of important strategic significance.

However, the integration between most individual technologies is disjointed, never forming the integrated technology system that can give play to overall effectiveness and the technology application models that suit the agro-ecological conditions in different regions, which is not conducive to the development of water recycling [18].

3.3 Strengthening the ecological protection and restoration, and enhancing the self-purification ability of the Dongting Lake water It is necessary to rationally develop the water resources in the Dongting Lake area, and enhance self-purification capacity of water body; give priority to the implementation of Dongting Lake wetland protection and restoration project; repair the water ecosystems, strengthen the construction and protection of ecological buffer zone; carry out comprehensive control over the rivers that go into Dongting Lake, and implement ecological restoration; promote the ecological treatment methods, to further reduce the amount of nitrogen and phosphorus into the lake; strengthen the study of eutrophication formation and elimination mechanism in Dongting Lake, algae growth and outbreak rule and natural water body restoration, and enhance the scientific and technological ability to support [7].

3.4 Strengthening the water quality monitoring, early warning and forecast in Dongting Lake To ensure the safety of water environment in the Dongting Lake area, it is necessary to set up many water quality monitoring stations in its tributaries, to control the water pollution of large and medium-sized industrial enterprises and cities.

Firstly, it is necessary to establish water quality monitoring system and implement the automatic measurement of various water quality indicators in the watershed to automatically send the results to the monitoring stations.

Secondly, it is necessary to establish multi-level remote monitoring system, to achieve the multi-level monitoring from regulatory agencies to monitoring stations.

Thirdly, it is necessary to establish mathematical model of water environment to provide early warning of water pollution [18].

References

[1] HUANG JG. Eco-environmental problems of wetland resources development and countermeasures in Dongting Lake Area[J]. Bulletin of Soil and Water Conservation, 2003, 23(1): 73-75. (in Chinese).

[2] ZENG GM, LU HW, JIN XC, *et al*. Assessment of the water quality and nutrition of the Dongting Lake with wavelet neural network[J]. Journal of Hunan University(Naturnal Science), 2005, 32 (1): 91-94. (in Chinese).

[3] HUANG DZ, WAN Q, LI LQ, *et al*. Changes of water quality and eutrophic

state in recent 20 years of Dongting Lake[J]. Research of Environmental Sciences, 2013, 26(1): 27 –33. (in Chinese).
[4] RAO JP, YI M, FU Z, *et al*. Research on water quality changes in Dongting Lake[J] . Yueyang Vocational Technical College, 2011, 26(3): 53 –57. (in Chinese).
[5] ZHOU H, OU FP, LIU Y. The analysis of the water quality and its change trend of Dongting Lake during the period of" Eleventh Five – Year" [J]. Journal of Hunan Institute of Science and Technology (Natural Sciences), 2011, 24 (2): 88 –90. (in Chinese).
[6] LI YZ, LIU F, ZHANG CM. Analysis of change trend of water environment and cause in the Dongting Lake wetland[J]. Ecology and Environmental Sciences, 2011, 20 (8 –9): 1295 –1300. (in Chinese).
[7] CAO CS. Dynamics of water quality of East Dongting Lake and cause analysis[D]. Hunan Agricultural University, 2012. (in Chinese).
[8] DOU HS, JIANG JH. Dongting Lake[M]. Hefei: Press of University of Science and Technology of China, 2000. (in Chinese).
[9] ZHONG RL, BAO ZY, ZHOU X, *et al*. Temporal-spatial evolution of water quality in Lake Dongting, China[J] . Journal of Lake Science, 2007, 19 (6): 677 –682. (in Chinese).
[10] ZHANG JM, YU JQ, LIU Y. Analysis on eutrophication evaluation index and its evaluation of Lake Dongting[J]. Inland Fisheries, 2006, 31(2): 43 –44. (in Chinese).
[11] DAI SB, YANG SL, ZHU J, *et al*. The role of Lake Dongting in regulating the sediment budget of the Yangtze River[J]. Hydrology and Earth System Sciences, 2005, 9(6): 692 –698.
[12] XU KH, MILLIMAN JD. Seasonal variations of sediment discharge from the Yangtze River before and after impoundment of the Three Gorges Dam [J]. Geomorphology, 2009, 104(34): 276 –283.
[13] CHANG J, LI JB, LU DQ, *et al*. The hydrological effect between Jingjiang River and Dongting Lake during the initial period of Three Gorges Project operation [J]. Journal of Geographical Sciences, 2010, 20(5): 771 –786.
[14] LI JB, QIN JX, WANG KL, *et al*. The response of environment system changes of Dongting Lake to hydrological situation[J]. Acta Geographica Sinica, 2004, 59(2): 239 –248.
[15] WANG W, LU SY, JIN XC, *et al*. The spatial distribution of sediments and overlying water N of Dongting Lake[J]. Environmental Science & Technology, 2010, 33(12F): 6 –10. (in Chinese).
[16] LE C, ZHA Y, SUN D, *et al*. Eutrophication of lake waters in China: cost, causes, and control[J]. Environmental Management, 2010 (45): 662 –668.
[17] XIAO SY, TANG JC, HUANG X, *et al*. Analysis on agricultural non-point source pollution of Dongting Lake and countermeasures[J]. Agro-environment and Development, 2008, 25(3): 72 – 75. (in Chinese).
[18] LI JF. The monitoring, evaluation and control of agricultural non-point source pollution of Hunan Province[D]. Hunan Agricultural University, 2009. (in Chinese).
[19] CHEN XH. Water environment evaluation and planning[M]. Guangzhou: Sun Yat-sen University Press, 2001. (in Chinese).

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whether this conclusion is still tenable when considering more image fusion algorithms or using other classification methods.

References

[1] ZHOU QX, JING ZL, JIANG SZ. Comments on research and development of multi-source information fusion for remote sensing images[J]. Journal of Astronautics, 2002, 23(5): 89 –94. (in Chinese).
[2] ZHANG NY, WU QY. Information influence on QuickBird images by Brovey fusion and wavelet fusion[J]. Remote Sensing Technology and Application, 2006, 21(1): 67 –70. (in Chinese).
[3] LI CH, XU HQ. Spectral fidelity in high-resolution remote sensing image fusion[J]. Geo-Information Science, 2008, 10(4): 520 – 526. (in Chinese).
[4] Kalpoma K A, Kudoh J. Image fusion processing for IKONOS 1-m color imagery[J]. IEEE Transactions on Geoscience and Remote Sensing, 2007, 45 (10): 3075 –3076.
[5] LIU J, LI DR, SHAO ZF. Fusion of remote sensing images based on fast discrete Curvelet transform[J]. Geomatics and Information Science of Wuhan University, 2011, 36(3): 333 –337. (in Chinese).
[6] WANG YL, TANG Y. Remote sensing image fusion based on multi-band wavelets[J]. Geomatics & Spatial Information Technology, 2010, 33(6): 16 –19. (in Chinese).
[7] TANG Y. Forest remote sensing image fusion based on multi-band wavelets [J]. Journal of Northeast Forestry University, 2010, 38(8): 68 –70. (in Chinese).
[8] QIU DH, WU YL, ZHANG RS. Fusion evaluation of Worldview-1 and SPOT5[J]. Journal of South west University (Natural Science Edition), 2010, 32(6): 168 –172. (in Chinese).
[9] ZHANG JW, SONG XD, YANG JA, *et al*. Comparison study on different fusion met hods based on ETM + image —A case study in Ansai and Yongshou County[J]. Journal of Northwest Forestry University, 2010, 25 (5): 152 –156. (in Chinese).
[10] LI JJ, HE LH, DAI JF, etal. Analysis of pixel-level remote sensing image fusion methods[J]. Geo-Information Science, 2008, 10(1):128 –134. (in Chinese).
[11] HAN SS, LI HT, GU HY. Study on image fusion for high spatial resolution remote sensing images[J]. Science of Surveying and Mapping, 2009, 34(5):60 –62. (in Chinese).
[12] Klonus S, Ehlers M. Performance of evaluation methods in image fusion [Z]. 12th International Conference on Information Fusion, Seattle, WA, USA, July 6 –9, 2009
[13] Pohl C,Van JLG. Multisensor image fusion in remote sensing: concepts, methods and applications[J]. International Journal of Remote Sensing, 1998, 19(5):823 –854.
[14] Liu JG. Smoothing filter-based intensity modulation: a spectral preserve image fusion technique for improving spatial details[J]. International Journal of Remote Sensing, 2000, 21(8): 3461 –3472.
[15] LI CG, LIU LY, WANG JH, *et al*. Comparison of two methods of fusing remote sensing images with fidelity of spectral information[J]. Journal of Image and Graphics, 2004, 9(11): 1376 –1387. (in Chinese).
[16] ZHAO ZM, MA W, WANG RS. Evaluation and analysis of three methods of fusing remote sensing images with high fidelity of spectral information [J]. Geology and Exploration, 2010, 46(4): 705 –710. (in Chinese).
[17] Ehlers M, Klonus S, strand PJ, etal. Multi-sensor image fusion for pan-sharpening in remote sensing[J]. International Journal of Image and Data Fusion, 2010, 1(1): 25 –45.
[18] TANG GA, ZHANG MS, LIU YM, *et al*. Digital remote sensing image processing[M]. Beijing: Science Press,2004:104 –107. (in Chinese).