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The Status Quo and Key Measures for the Treatment of Cyanobacteria Outbreak in Taihu Lake

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Abstract: The water supply crisis in Taihu Lake happened in 2007; the effect of alleviating the eutrophication of Taihu Lake was achieved, in more than 10 years of treatment year after. The average annual water quality of Taihu Lake in 2019 improved from Surface Water Quality Grade V to Grade IV, which the total nitrogen (TN) was reduced by 36.6%; The treatment effect was not ideal, the area of annual cyanobacteria outbreak was still very large, the largest area in 2017 exceeded by 43% than the largest area in 2007, the algal density of the whole lake generally increased, the chlorophyll a increased by double, the total phosphorus of Surface Water Quality Standards did not fall down, but went up. We analyzed the causes of the problems; we would like to put forward the goal of eliminating cyanobacteria outbreaks between 2030 and 2049 by following three major key measures---alleviating eutrophication, reducing cyanobacteria blooms and restoring wetlands. We suggest that we revise Taihu Lake basin water environment comprehensive management plan once again and put eliminating cyanobacteria outbreak into 14th Five-Year Program and the Yangtze River Protection Law; to change the policy from merely controlling eutrophication and reducing cyanobacteria together. On the basis of controlling eutrophication we could adopt eliminating cyanobacteria by zoning and multiple cyanobacteria removal technology; restoring wetlands in large scale; finally, eliminating cyanobacteria outbreaks.

Keywords: Taihu Lake; cyanobacteria outbreak; status quo of governance; key measures.

Taihu Lake is China's 3rd largest freshwater lake, the China's largest freshwater lake in the dry period, the average annual water storage for many years 4.75 billion m3, water depth of 2.05 meters, the lake shore line length of 436 km, of which 290 km of the embankment, could be a closed shallow water lake, located in the southern plains of the Yangtze River Delta, is one of the most densely populated and socio-economically developed areas of the country [1].

1. Treatment measures

It has been more than 30 years since 1990 with the outbreak of cyanobacteria[2], especially since the water supply crisis in Taihu Lake in May 29, 2007, the state and local governments have invested heavily, manpower and material resources to take comprehensive measures to treat environmental problems in Taihu Lake for more than 10 years: controlling pollution sources, improving sewage treatment capacity and sewage pipeline network, reaching the first level A emission standard, controlling sewage, industrial wastewater, large-scale centralized aquaculture and other face sources, such as fields and villages, shutting down or removing more than 3000 heavy pollution enterprises, etc.; According to the data we harvested 14.5 million m3 cyanobacteria for harmless disposal and utilization as resource during the period between 2007 and 2018. Wangyu River introduced 9.3 billion m3 of water from the Yangtze River to save Taihu Lake from 2007 to 2018. Meiliang Lake (a bay of Taihu Lake, with an area of 124 km2) discharged 8.9 billion m3 its water out of the bay, which took away large amount of TN, TP, cyanobacteria source and organic matter. We dredged the silt of 35 million m3 in Taihu Lake, removing large amount of TN, total phosphorus, cyanobacteria and organic matter pollutants in the mud; We recovered the reed wetland with an area of 37 km2 in Eastern Taihu and sporadic repairs have been carried out in other waters.[3]

2. Treatment effects

Through more than 10 years of governance, we achieved better results in phase, reduced the level of eutrophication, The water quality of Taihu has been improved to a considerable extent, In 2019 The water quality of Taihu Lake upgraded from 2007 Grade V to Grade IV in 2019, in which TN from 2.35 mg/L reduced down to 1.49 mg/mg/L, cut by 36.6%, Taihu water functional area compliance rate increased from 22.5% in 2007 to 58.3% in 2017[4]; since then there is no lake upsurge and odor water body in Gong Lake, a small northern bay of Taihu Lake, thus the water supply can be guaranteed in Wuxi.

3. Present problems

3.1 The level of cyanobacteria outbreak did not be mitigated

Each year, the area of cyanobacteria outbreaks is different in size due to meteorological and hydrodynamic factors, but the overall cyanobacteria upsurges (here after referred to as "cyanobacteria outbreaks") are still serious. At the end of December 2016, the area of cyanobacteria outbreaks exceeded 700 km2. The largest area of cyanobacteria outbreaks in Taihu Lake reached 1403 km2 in 2017, an increase of 43% than 979 km2 in 2007. The largest area of cyanobacteria outbreaks reached 1071 km2 in May 24, 2020, an increase of 9.4% than 2007. The average annual density of cyanobacteria in Taihu Lake and Meiliang Lake was 117 and 240 million cells/L, respectively in 2017, an increase of 5.05 and 3.43 times, respectively over 2009, and the concentration of Chlorophyll more than doubled during the same period[4].

3.2 The total nitrogen in Taihu Lake

The average annual water quality of Taihu Lake was upgraded from inferior Grade V in 2007 to Grade IV in 2019, but from 2015 the total phosphorus did not decrease, but went up, more than the total phosphorus (TP) in 2007 (still in Grade IV range) and the total phosphorus 0.087 mg/L in 2019 is 0.7%, higher than 0.074 mg/L in 2007, an increase by 17.6%, and the water quality of Zhushan Lake and the western coastal waters remained in the inferior Grade V while the total phosphorus of Eastern Taihu Lake were at Grade III in the period of 2007-2012, downgraded to Grade IV for the period of 2017-2018 [4].

The reasons are: (1) the total phosphorus load of the inflow waterways surrounding Taihu Lake increased; (2) the total phosphorus released from the sediment increased. After many years of cyanobacteria outbreaks, large amount of cyanobacteria sunk to the bottom of the lake after death and increased the nitrogen and phosphorus elements whereas the original insoluble phosphorus in the sediment (including the original phosphorus in the sediment and the phosphorus of the dead cyanobacteria) in anaerobic conditions changing to soluble phosphorus releasing into the water; (3)The increase in algae density leads to an increase in the phosphorus content of algae source in water.

3.3 Reduction of the inflow pollution load from river to lake slow

Nowadays, there are 18 inflow rivers into Taihu Lake. Their total nitrogen all was inferior Grade V in 2018; the total phosphorus of 14 rivers was at Grade IV to Grade V, another four rivers inferior Surface Water Quality Standards Grade V [5]. For example, in 2017, the total inflow load of TN was 39,400 tons, the total inflow load of total phosphorus was 2000 tons, accounting for 92.5% and 105%, respectively of 42,600 tons TN, 1900 tons TP in 2007 i.e. the TN flowing into Taihu lake was reduced by only 7.5% whereas the total phosphorus increased by 5%. It shows that the control of inflow sources in the basin was not strong enough to keep up with the increase in the rate of pollution load caused by population growth and sustained social and economic development.

3.4 There is still a potential of cyanobacteria outbreak which will lead to water supply crisis like “Lake-upsurge” in Taihu Lake [6]. We have to earnestly study the reasons although the TN of water quality in Taihu Lake had been improved, the cyanobacteria still possibly outbreak. In 2018, the governments have established Lake Chief responsibility system for lake and river in Taihu Lake basin and the state put forward Great Protection Strategy of the Yangtze River. This is also the best mechanism and good opportunity to eliminate cyanobacteria outbreaks, and an indispensable part of the management of Taihu Lake water ecological environment.

4. Key treatment measures taken

The key measures to eliminate cyanobacteria outbreaks in Taihu Lake are to establish the goal of eliminating cyanobacteria outbreaks and to adopt three technical measures to alleviate eutrophication, to remove cyanobacteria and to restore wetlands.

4.1 To set up the final goal of eliminating cyanobacteria outbreaks

Since 1990 the first cyanobacteria outbreak in large scale in Taihu Lake, the state has not set a goal yet for the elimination of cyanobacteria outbreaks. The State Council had Taihu Lake Basin Water Environment Comprehensive Management Scenario in 2008 and Taihu Lake Basin Water Environment Comprehensive Management Scenario (revision) in 2013[7], [8]. But in these two scenarios and the relevant documents at all levels of government as well did not put forward the goal of eliminating cyanobacteria outbreaks. Therefore, when we determine that the final goal for Taihu Lake water functions should reach to Surface Water Quality Grade II-III, facing the cyanobacteria outbreak problem, at the same time, we suggest that the final goal should include the elimination of cyanobacteria outbreak in the period of 2030-2049 (the centennial founding year of People’s Republic of China)[9]. The ecological environment might be fundamentally improved.

The final goal of eliminating cyanobacteria outbreaks can raise the responsibility, initiative and enthusiasm of Lake or River Chiefs and science technology researchers at all levels to eliminate cyanobacteria outbreaks; we can encourage people's fighting spirit and improve supervision work. Dare not set up goals or fear eliminating cyanobacteria outbreaks should be removed.

4.2 To strengthen controlling external-pollutant source

Why has the total phosphorus load not been decreased after more than 10 years of efforts to control in Taihu Lake? First, during this period, the population of the basin increased from 50 million to 60 million, an increase of 20%, the socio-economic sustained development, the GDP increased nearly 2 times, the water consumption increased by 50-80%[10], the pollution load and water inflow continued to increase; secondly, the original control strength was smaller, which can not satisfy the environmental requirements.

Reducing external pollutant sources is the basic measure to alleviate up or dispel the eutrophication. We should increase the efforts to reduce external pollutant sources in an all-round way, and in faster than the speed of social and economic sustained development to increase the pollutant load, so as to effectively reduce the total phosphorus load of inflow waterways.

Reduction of external pollutant sources include: four types of point pollutant sources, all efforts to reduce sewage, industrial wastewater, centralized animal husbandry and sewage/wastewater treatment plants. Moreover, we must adopt strict classified disposal of wastes, to shut down and turn heavy pollution enterprises off; industrial enterprises must enter into industrial parks, rain and sewage should adopt classified treatment; Wastes from large-scale livestock poultry breeding and aquaculture farms should get through centralized treatment; crop fields need to control agricultural chemicals dosage, to promote the use of organic fertilizer and water-saving irrigation. At the same time, the rapid development of rural tourism should be strictly controlled in Dongshan and Xishan so as to reduce much sewage and garbage in the eastern coastal waters of Taihu Lake.

4.3 To upgrade the treatment standards of wastewater plants

4.3.1 Wastewater treatment plants are the largest point pollutant source group

Nowadays, the total nitrogen and total phosphorus of the urban wastewater treatment plant Level 1 A Emissions Standards are 15 mg/L and 0.5 mg/L[11], while the total nitrogen and total phosphorus of Surface Water Quality Standards (lake) Grade III are 1 mg/L and 0.05 mg/L[5]. Although the wastewater total nitrogen and total phosphorus of treatment Level 1A emissions standards can be reduced from 55% to 70% of the nitrogen and from 70% to 85% of the phosphorus [3], but N P of its discharging water is still equivalent to more than the environmental capacity of Taihu Lake, such as other unprocessed point pollutant sources and a large number of surface pollutant sources discharged into the water body N P, would be more than the environmental capacity [12]. Therefore, the wastewater treatment plant (facility) might be the largest point pollutant source group in the Taihu Lake Basin. The current emissions standards are too low. On the basis of improved wastewater treatment capacity and building a fully covered wastewater collection network and strengthening management, the upper reaches of Taihu Lake should greatly upgrade their wastewater treatment standards, and at the same time comprehensively and effectively control other sources in order to meet the environmental capacity requirements of Taihu Lake.

4.3.2 Upgrade the standards of wastewater treatment

For domestic sewage treatment plant (facility) in the upper reaches of Taihu Lake areas, the TN emissions of discharging water could be firstly upgraded to Surface Water Quality (lake) Standards Grade II -III (0.5 - 1 mg/L), firstly upgraded to 3 - 4 mg/L in recent year (2030); the total phosphorus could be upgraded to Surface Water Quality Standards Grade II-III (0.025-0.05 mg/L), upgraded to 0.1 mg/L in the near future.

It is estimated that the sewage treatment plants would upgrade emissions standards of the discharging water and also significantly reduce the pollutant load of other types of surface pollutant source; it might satisfy the requirements of environmental capacity of Taihu Lake. The sewage plants in the non-upper reach areas of Taihu Lake could be upgraded less than those values. On the basis of summing up the experience of sewage treatment in various places, the municipalities in the basin could adopt local legislation to formulate more stringent emissions standards of discharging water than wastewater treatment Level 1A in accordance with the requirements of population density, socio-economic development characteristics and the environmental capacity of rivers and lakes.

4.3.3 It is feasible to enlarge the range of emissions standards of wastewater treatment plants

The composite high-efficiency fix-installed microorganisms technology of Beijing Xinnohua Company [13] for domestic sewage treatment plants, the TN of emissions can reach the range of Surface Water Quality Grade II-III (0.5 - 1 mg/L); the total nitrogen of emissions of mixed sewage and industrial wastewater treatment

plants can reach 3-4 mg/L; using the short range anaerobic ammoniated oxygenated ion gas floating technology of Wuxi Mester Environmental Technology Company the total phosphorus emission could reach to 0.01 mg/L[14]. Through technology exchanges, the emissions standards of the wastewater treatment plants could be comprehensively upgraded.

4.3.4 Strengthen sewage treatment capacity to reduce emissions of discharging water pollutant load

All urban domestic sewage in the upper reaches of the basin must go into sewage treatment plants, scattered sewage should be treated by small facilities; Industrial wastewater should be treated to reduce pollutants through structure and technology, its wastewater should be treated by itself or when it reaches the standards for pipe to takeover to connect to the wastewater treatment plants; Barn sewage from large-scale farms should be treated centrally by using new technologies such as fix-installed microorganisms technology[13], the government would give some appropriate subsidies or for effective resource utilization. The runoff in cities and towns should be treated by appropriate technology and equipment.

4.4 Clean up cyanobacteria the main endogenous source of eutrophy

4.4.1 Cyanobacteria are the current main endogenous pollutant source

Endogenous sources of eutrophy include bottom mud, biological residues and cyanobacteria. Before cyanobacteria outbreaks, sediment mud is the main endogenous source of Taihu Lake; after the first cyanobacteria outbreak in 1990, cyanobacteria sustained to outbreak, through life and death cycle, living and dead cyanobacteria gradually became the main endogenous source in the substrate and water body, and so that the original insoluble phosphorus in the sediment can also be converted into soluble phosphorus. Therefore, it is necessary to remove the cyanobacteria from the surface water body and the upper layer of the sediment. At present, we only conduct removal project in the original bottom mud, its investment is large but with little effects, so it is difficult to reduce the concentration of phosphorus. The concept that cyanobacteria do not belong to endogenous source is not correct.

4.4.2 Clearing endogenous source of eutrophy requires:

(1) To use conventional dredging machine to remove the bottom mud with large amount of cyanobacteria sunk area, the silt could be used as backfill to raise the foundation of the restored reed wetlands. This can kill three birds with one stone: reducing and drying silt dumps, saving investment by 64% [12], and help restore reed wetlands. The silt could be fully utilized as resources. In the same time, too much vascular plants and aquaculture pollutant load could be greatly improved.

(2) Remove cyanobacteria.

Integrated inhibiting and eliminating or algicides technologies have been adopted to remove cyanobacteria in surface water and sediment, N P could be significantly reduced; especially the total phosphorus. It is difficult to achieve the results, only by reducing pollutant sources on land and conventional removal of the bottom mud technology. The technology of removing both cyanobacteria in water body and bottom mud at the same time has been innovated, such as (4.7.1) composite living water regional eliminating cyanobacteria technologies [16] could remove cyanobacteria and organic mud pollution in long term with simultaneous purification of water bodies. Moreover, new methods for dredging silt have been invented, for example, “Fix-installed microorganisms dredging”, “Optical quantum carriers dredging” and other “Long run purifying water and dredging technology”. The principle of light quantum carrier dredging is to plant the energy into the carrier; when the carrier enters the water body, it will release the light quantum energy and will purify the water body and the bottom mud at the same time.

4.5 The combination of harnessing cyanobacteria and managing eutrophication can eliminate cyanobacteria outbreaks.

"To control the water pollution in Taihu Lake is first to treat its root on shore.” It is correct to alleviate its eutrophication. However, the point of view that management on eutrophication can eliminate cyanobacteria outbreaks" is not appropriate. Domestic and foreign experts generally believe if cyanobacteria outbreaks have already occurred in those large or medium shallow lakes, the elimination of cyanobacteria only depend on alleviation of eutrophication, the total nitrogen and phosphorus of water must reach 0.1 ~ 0.2 mg/L and 0.01 ~ 0.02 mg/L, respectively[3]. It is difficult to achieve those values by virtue of dense population and socio-economic development in Taihu Lake Basin. Therefore, only relying on the management of eutrophication cannot eliminate cyanobacteria outbreaks. The combination of alleviation of eutrophication and reduction of the large amount of cyanobacteria might eliminate cyanobacteria outbreaks.

4.6 Harnessing cyanobacteria of the lake by zoning waters

4.6.1 To remove cyanobacteria by zoning waters

The area of Taihu Lake is rather large, with strong wind and waves. It is not possible to eliminate the cyanobacteria outbreaks in the whole lake once. The fundamental conditions for eliminating cyanobacteria outbreaks are zoning governance, i.e. the construction of a number of enclosed water zones. the techniques and experience in eliminating cyanobacteria outbreaks or basically eliminating cyanobacteria outbreaks of small lakes, such as East Lake in Wuhan, Xuanwu Lake in Nanjing, West Lake in Hangzhou and Wuli Lake in Wuxi could be utilized as a model of zoning waters in Taihu Lake water basin.

4.6.2 Boundaries of zoning waters

It is required that each water should be relatively closed and have a certain hydro-connection and water exchange with the adjacent waters, and A cofferdam must be built at the boundaries of the zoning waters, which could block cyanobacteria, winds and waves. If the wind and waves strong in a large zoning waters we could use wire stone cage even the dam (earth dam at the lower part) or to use bamboo piles, wooden piles, cement piles (plus filtering cloth) combined facilities, conducive to the simultaneous improvement of the two sides of the water environment; in smaller wind and wave zoning waters fixed or soft cofferdam could be used.

4.6.3 The sequence of algae removal in zoning waters

First eliminate the cyanobacteria outbreaks in Meiliang Lake, Gong Lake, Zhushan Lake and other lake bays, these waters could also be divided into smaller zoning waters, adopting cyanobacteria outbreak management technology in small lakes and integrating related technologies and innovations of algae removal in various waters, and then to eliminate cyanobacteria outbreaks in the central lake waters and other waters.

4.7 Algal removal technology

In the past, cyanobacteria were collected during the outbreak of cyanobacteria on the surface of the water, and after more than 10 years of collection, it played a role in eliminating the high density of cyanobacteria and improving the sense of smell and visual effects. It is estimated that the current amount of cyanobacteria harvested from the surface of the water accounted for only 2% to 4% of the annual production of cyanobacteria in Taihu Lake. However, objectively, the more cyanobacteria harvested, the more cyanobacteria grow. It indicated that the collection method needs to improve. We may adopt new methods of harvesting cyanobacteria, to strengthen efforts to reduce endogenous nutrients, to implement year-round water collection harvesting both cyanobacteria on surface water bodies and dead cyanobacteria sunk into the sediment strategy, to eliminate cyanobacteria outbreaks by zoning waters; to keep zoning waters free of cyanobacteria for several years, and then, connected zoning areas to stretches of zoning areas without cyanobacteria. The removal of cyanobacteria (referred to as algae removal) includes inhibiting the growth and reproduction of cyanobacteria and the direct elimination of cyanobacteria. In addition there are many types of algicides by physical, chemical and biological means, in addition to the harvesting of surface cyanobacteria, to directly damage one or more functions of cyanobacteria, such as buoyant force, phosphorus absorption, phosphorus storage, photosynthesis, chlorophyll formation, etc., to inhibit its growth and reproduction or make it die.

4.7.1 Diamond Membrane Carbon Nano-Electronic Algal Removal Technology [13]

Introduction to "diamond membrane carbon nano coordinated super-purifying water and silt co-treatment technology"

The core device of its technology is the diamond membrane nano-carbon material electrode system with negative electron affinity, with the earth as the positive pole, the device core module as the negative pole, to achieve a large number of electrons emitted by clusters under the low voltage weak electric field in water, forming a large number of carbon-based skeleton discrete structure microelectronic and photo catalytic effects occur with organic complexes in water, releasing high-energy electrons, while in light, high-efficiency photo absorption and interaction, and photo catalytic oxidation, rapidly increase the concentration of active dissolved oxygen, gradually dispersed, decomposed, REDOX contaminants, some of which become microbial baits, promote beneficial biological growth, and some degrade to H2O, CO2, etc.

The technical principle is to emit electrons through the device, and under the sunlight conditions, an efficient photo catalytic REDOX reaction.

(1) Increase the dissolved oxygen of the water body to eliminate the black odor reaction occurs in the water body to eliminate the polluting substances; (2)Remove ammonia nitrogen，total nitrogen;(3) Remove COD organic matter; (4) Remove total phosphorus; (5) Reduce cyanobacteria; The electrode device of this technology releases electrons after voltage addition, creating photo-electronic effects and photo-catalytic effects in sunlight,

destroying the cell walls and intracellular materials of cyanobacteria, and eliminating cyanobacteria. This technology eliminates cyanobacteria with high efficiency, does not need chemicals, saves labor, easy management, it can run all seasons, while reducing other pollutants in water bodies and sediment; (6) reduce organic silt; (7) Manage heavy metal [15].

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4.7.2 Composite local living water cycle eliminating algae technology

The key is to use a variety of: There are five functional templates (modules) made of new composite materials: living water circulation, energy release, fix-installed indigenous microorganisms, nano-carbon nuclear magnetism, and advanced oxidation. They are composite overlaid, under the action of solar microelectronic field, to achieve electronic leap, organic complex REDOX discrete and generate a large number of carbon points, which can efficiently use visible light energy, stereoscopic chain photo catalysis, cycle deconstruct water molecules, produce hydrogen, oxygen, hydroxyl free radicals, super-oxygen anion free radicals and other reactive oxygen, eliminating water, mud pollution and cyanobacteria cells damage, aging, death, floating or oxidation, sinking, then fed by microorganisms, plankton aquatic animals.

4.7.3 High-pressure algae removal technology [15]

High-pressure algae removal technology means to treat cyanobacteria when they enter the high-pressure equipment by high-pressure. The original pressure, temperature and other habitats of cyanobacteria were changed so that to a considerable extent cyanobacteria lost their ability to grow and reproduce, or even die, to reduce the effect of cyanobacteria. High-pressure algae removal includes two categories: shaft-type and mobile. If the tail water of high-pressure algae removal equipment for algae water separation treatment, algae removal effect is better. Moreover, push-flow aeration and ultrasonic sonic [16] have the same algae removal effects.

4.7.4 Algal removal technology by modified clay

It is algal removal technology by use of mechanical equipment to quickly spray modified clay water solution, so that cyanobacteria on the surface water would be quickly sunk to the bottom, and then, to implement ecological restoration e.g. planting submerged macrophytes, to fix the mud which in turn to absorb the nutrients contained in cyanobacteria, to eliminate algae. Other substances, such as natural mineral purified water or similar substances have algal removal effects.

4.7.5 Competition among bio species to remove algae.

It would utilize wetlands to cultivate reedy plants, floating macrophytes: purple root water hyacinth, submerged macrophytes or use allelopathy preparations to compete with cyanobacteria, to utilize the competition between algal species to cultivate diatom, in addition to use aquatic animals, filtering fish: silver carp bighead carp to feed cyanobacteria.

4.7.6 To inhibit or eliminate algae by safe high effective microorganisms and their preparation

There are many highly effective microorganisms that can inhibit the growth and reproduction of cyanobacteria or kill them directly. The key is to choose safe microorganisms. It is better to set up certain safety appraisal institute for cyanobacteria to carry out safety scientific identification of various technologies, to allow

the use of safety products, or provide safety guidance for technology, especially to innovate and promote the algicides and inhibiting products of indigenous microorganisms.

4.7.7 Integrated algae removal

It is based on the zoning waters to use of the above-mentioned several algae removal technologies reasonably combined and integrated to reduce algae density up to the elimination of cyanobacteria outbreaks. In short, we cannot wait for the days when Taihu Lake naturally becomes from algae-type Lake to grass-type Lake so as to eliminate cyanobacteria outbreaks. We should summarize on the basis of many existing algae removal technologies, to integrate the innovations, and scientifically manage Taihu Lake, so that Taihu Lake might become a clean and beautiful lake from algae-type to grass-typed lake, before the elimination of cyanobacteria outbreaks.

4.8 Large-scale restoration of wetlands

The current wetland area in Taihu Lake is 450 km2 reducing more than 200 km2 in the 1960s and 1970s, reducing the ability to purify water and algae. Wetlands should be restored, with vegetation coverage reaching 25-30% before the cyanobacteria outbreak. The thoughts that the conditions for the restoration of wetlands are immature or it is difficult for algae-type lakes to restore wetlands are not correct.

4.8.1 Reasons for the reduction of Wetlands in Taihu Lake

The reasons for the serious damage to the wetlands in Taihu Lake: construction of the ring lake levee, to reclaim land from marshes for cultivation and aquaculture, serious water pollution, large-scale outbreak of cyanobacteria, raising the water level in winter and spring. According to the investigation, the construction of Taihu Lake in the western part of Taihu Lake and Zhushan Lake was built; the wetlands along the lakeside were reduced by 70 km2. The water pollution and cyanobacteria outbreaks made Gong Lake and Zhushan Lake lost 30 km2 and 20 km2 of submerged macrophyte wetlands, respectively.

4.8.2 Restoration of multiple wetlands

The restoration of wetlands is carried out in sync with the improvement of habitats, during which algae- type lakes are also changed to grass- type lakes.

(1) Repair coastal wetlands: the wetlands off the coast 500 to 1000 m or wider first. The most of coastal waters in Taihu Lake could be restored wetlands along the 436 km coastal line. Habitats need improved first: ① The restoration of wetlands in wider waters need to set up anti -wind and wave facilities on its periphery, such as the installation of iron wire stone cage dam or fence; ②Restoring reed wetlands mainly for lessening wind and wave, to control water depth, raising or decreasing the water depth so as to make wetlands no water in winter and spring; ③Repairing submerged macrophyte wetlands, firstly, using modified clay, nano-carbon electronics and phosphorus locking agents to eliminate pollution and cyanobacteria outbreaks, to control benthic fish stir mud and other measures to increase water transparency, and then repair the submerged macrophyte wetlands; ④In bay zoning and central zoning waters, properly decrease the water depth and increase the transparency, the wetlands would form by both natural and artificial restoration.

(2) Restoring the reclaimed wetlands. Mainly to dismantle the western ring Taihu Lake levee, return to the lake, restore coastal waters originally reclaimed wetlands 30 to 50 km2, and restore other waters of the reclaimed part of the wetlands. It is said: the oversea of Tianchi Lake in Yunnan has already dismantled 48 km lake ring levee, restored 9 km2 wetlands. The case is worth learning from. Taihu Lake could also restore the western wetlands of Taihu Lake or might modify in another appropriate way to make the water bodies on both sides of the levee flow each other, such as opening several gaps in the levee around the lake and set up several gaps to connect the water two sides water or to build a bridge on the gap and becoming a wetland, so that the polluted river may flow into Taihu Lake to be purified through the wetland, and then through the bridge culvert of the levee into the lake, so that the wetlands could also play a role in reducing the water pollution.

(3) Reduce water levels and increase wetlands. Appropriately reduce the water level in winter and spring, it is calculated that if we reduce the depth of water by 50 cm, we can increase the wetland by 14 km2, and at the same time, it is good for the germination and growth of reeds and other plants in spring, which is good for the artificial restoration of wetlands, and it is possible to reduce the water level in other seasons, which can improve the underwater lighting and help the natural restoration of the submerged macrophyte community in the heart of the lake.

(4) The term allelopathy refers to the mutual rejection or promotion of plants by releasing specific metabolites to the environment during their growth and development, changing the micro-ecological environment around them and affecting the growth and development of other surrounding plants. There are many plants in the lake, the allelopathy chemical effect not only exists between floating macrophytes such as

water hyacinth but also between various types of algae, India has adopted the micronutrient iron-containing Nualgi, to promote the growth of diatoms, to compete with cyanobacteria and green algae. See ref [26][27].

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4.8.3 Scientifically formulate a special plan for the restoration of wetlands in Taihu Lake, drawing on the experience of the restoration of 37 km2 reed wetlands in the period of 2012-2015 [3] and the small-scale restoration of wetlands in waters such as Sanshan Island in the eastern part of Taihu and Yixing City in the west, and design a special planning plan for the artificial restoration of Taihu Lake and the wetlands in various lakes and waters. Restoring the Taihu Wetlands to the scale before the cyanobacteria outbreak, artificial restoration promotes the natural restoration of wetlands; set up a professional wetland management team, to harvest reeds in winter, to control the submerged aquatic plants crazy growth. The Government should allocate funds for the management of wetlands in the same way as the conservation of park grasslands.

4.9 To build cyanobacteria elimination demonstration district

4.9.1 To put eliminating cyanobacteria as an important research project in management of Taihu Lake

Set up a multidisciplinary joint research team to promote the elimination of cyanobacteria outbreak technology to emphasize the transformation, popularization and application of achievements. Scientific research should focus on applied technology research taking into account basic theoretical research, that is, the focus should be on the elimination of cyanobacteria outbreak of integrated technology and practical research.

4.9.2 The comprehensive algae removal test of zoning waters

Meiliang Lake was used as the algae-removal test zoning waters. The natural geographical conditions of Meiliang Lake are advantageous to construct relatively closed zoning water, with good basic conditions for governance, and Meiliang Lake is a well-known scenic spot in the country, the whole country is extremely concerned about the elimination of cyanobacteria outbreaks. Comprehensive algae removal tests include: setting up a barrier that can withstand strong wind and heavy waves, permeable water, blocking the entry of cyanobacteria from Taihu Lake proper flow into Meiliang Lake; It is estimated that it will take 10 years to complete the test, the areas free of cyanobacteria outbreak can connect together to be a whole piece of cyanobacteria free. Algae removal plan in Gong Lake and Zhushan Lake can be carried out next to the algae removal test in Meiliang Lake or at the same time as algae removal test zoning water in Meiliang Lake.

4.9.3 Increase scientific research investment and public sharing of information.

The use of national, local government and private capital and other forms of gathering funds could increase investment in scientific research, strengthen the monitoring of water quality, cyanobacteria and its outbreaks and other projects. We should increase one item of monitoring to monitor cyanobacteria dry matter, because this indicator is better than monitoring algae cell density and chlorophyll a and it can explain the severity of cyanobacteria outbreaks;

4.10 Develop practical plans

In the past, the two overall or revised programs for the comprehensive management of the water environment in Taihu Lake have only the goal of treating the eutrophication of the lake. Therefore, it is suggested that the third preparation (reform) of the Taihu Basin water environment comprehensive management planning program, as well as the National 14th Five-Year Plan and the National Yangtze River Protection Law, to eliminate the cyanobacteria outbreak target and its corresponding integrated measures of governance technology included. Planning plan to "work, good use, solve the problem": to solve the world problem of cyanobacteria outbreak of Taihu Lake, the Chinese government and people have the ability, after 1-3 Five-Year Plan, that is, 2020-2035 to eliminate Meiliang Lake, Gong Lake (East Lake Bay in the north of Taihu Province.) 164 km2), Zhushan Lake (West Lake Bay, 68 km2 in the north of Taihu Province) cyanobacteria outbreak, and improve the water quality of Taihu Lake to II.-III. By 2049 to eliminate other waters of Taihu cyanobacteria outbreaks and maintain the East Taihu cyanobacteria outbreak.

5. Conclusion

In the process of implementing the Lake Chief System [22] and furthermore promoting the River Chief System [23], guided by the problem of sustained cyanobacteria outbreaks on a large scale, a new round of Taihu Lake management work has been carried out so as to mobilize Lake and River Chiefs and Leaders at all governmental levels, science and technology researchers and the general public. It could raise enthusiasm, initiative and creativity of the people. It might put forward the elimination of cyanobacteria outbreak as our final goals. Upgrading wastewater treatment, integration of many innovative treatment measures of cyanobacteria and basic scientific research, we believe that the national efforts would be able to finally solve the problem of cyanobacteria outbreak in Taihu Lake early days, will ensure safe water supply to meet the people, tourists landscape, leisure and other hydro-water requirements, so that people have more to enhance the ecological environment of the sense of access and happiness, so that Taihu Lake to become the people look forward to better ecological civilization of the beautiful Taihu Lake, free of the cyanobacteria outbreak

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