The Research Progress and Comprehensive Treatment of Lake Eutrophication in China
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1. Current Situation of Lake Eutrophication in China
1. Methods to assess Eutrophication in China

TLI is mainly used as follows.

1. \( \text{TLI} (\text{chla}) = 10 \left( 2.5 + 1.086 \ln \text{chla} \right) \)
2. \( \text{TLI} (\text{TP}) = 10 \left( 9.436 + 1.624 \ln \text{TP} \right) \)
3. \( \text{TLI} (\text{TN}) = 10 \left( 5.453 + 1.694 \ln \text{TN} \right) \)
4. \( \text{TLI} (\text{SD}) = 10 \left( 5.118 - 1.94 \ln \text{SD} \right) \)
5. \( \text{TLI} (\text{COD}_{\text{Mn}}) = 10 \left( 0.109 + 2.661 \ln \text{COD} \right) \)

Unit: \( \text{chla}: \text{mg/m}^3, \text{SD}: \text{m}, \text{Others}: \text{mg/L} \)

**Assessing Standards**

<table>
<thead>
<tr>
<th>TLI(∑)</th>
<th>0</th>
<th>30</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient Level</td>
<td>Low Nutrient Level</td>
<td>Medium Nutrient Level</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>High Nutrient Level (Eutrophication)</td>
</tr>
</tbody>
</table>
2. Current Situation of Lake Eutrophication in China

Main Lake region in China
- Lakes in Eastern Plain Area
- Lakes in Northeast Plain and Mountain Area
- Lakes in Qinghai-Tibet Plateau Area
- Lakes in Inner Mongolia-Xinjiang Plateau Area
- Lakes in Yunan-Guizhou Plateau Area

Number of Lakes: 2742 (> 1 km²)
Total Area: 91020 km²
Based on investigation of 26 lakes in China, the number of eutrophication lakes in China in the 1970s, 1980s and 1990s is 27%, 61% and 85% respectively. In 2000, it develops faster and China has become a heavy eutrophication country in the world.
Total Area of Eutrophication Lakes

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2006</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Area (km²)</td>
<td>3800</td>
<td>5000</td>
<td>6700</td>
</tr>
</tbody>
</table>

Distribution of Eutrophication Lakes in China

- **East**: 56.7%
- **Midland**: 29.9%
- **West**: 13.4%
Sea gourds of Kunming Lake

Waterweeds of Chao Lake

Taihu Lake

Meiliang Bay of Taihu Lake
Annual water quality of Taihu Lake

Example-Taihu Lake
Annual Water Quality of Chaohu Lake

Permanganate Index (mg/L)

Total Phosphorus (mg/L)

Total Nitrogen (mg/L)

Nutrient Condition Index
Area of Blue Algae Bloom in Taihu Lake from 1950 to 2006
2. Research Progress of Lake Eutrophication in China
Since the 1950s, China has started to concern about lake eutrophication and carry out specific research on aquatic organisms, planktons, and types of eutrophication. Especially in recent 20 years, Chinese researchers have done a lot of basic study on lake eutrophication control and econological restoration. In practices, many successful experiences have been achieved. Major research fields include:

- Study on eutrophication source, limiting factors and adjusting strategies
- Study on form, release patterns, influence factors and transformation mechanisms of source nutrient in lakes
- Study on rules of transport and transformation of N and P from agricultural non-point pollution
- Application of Remote Sensing Technology in dynamic monitoring of lake eutrophication
- Study on models of lake eutrophication prediction
Sample Collection of Water and Hydrophyte

Environment monitoring

Water collection

Hydrophyte collection

Sediment collection
Remote Sensing Monitoring of Water Quality

Taihu Lake

Mouth of the Pearl River

Kunming Lake

Sequence remote sensing monitoring of water quality for long period
2. Insufficiencies

In the Field of Research:
Domestic study on nutrient source is much more focusing on monitoring and research of regular nutrient indices (TN, ammonia nitrogen, nitrate nitrogen, TP, COD, SS). It lacks analysis on identification, labelling, transport and transformation of nutrient of different forms, especially lacking basic research on transport and transformation of P (Dissolved Phosphorus and Particulate Phosphorus).

In the Field of Technical Promotion
In the Chinese mainland, there is some difference in technical level, such as remote sensing monitoring and building of pollution data base, especially between western and eastern coastal area,

In the Field of Policy:
Some local authorities only pursue economic benefits and encourage the fast expansion of industries and enterprises. Some enterprises with high pollution and high energy consumption still exist.
3. Solutions of Eutrophication Treatment in China
Characteristics of water remains largely.
Social Circulation of Water

Natural Precipitation

↓↓↓↓↓↓↓

Manufacture and Daily Life

Uptake

Rivers and Lakes

Treatment

Characteristics of water changes constantly.
1. Keep natural circulation of water and secure it as clean water source for down areas.

2. Regulate social circulation of water and reduce anthropogenic pollution.

3. Preserve or restore ecological condition of lakes. Balance the ecosystem and play its functions.
General Thoughts on Comprehensive Treatment of Basins

Population and Distribution
Economic Developing Patterns
Circular Economy Cleaner Production

Pollution Source
- Wastewater from towns and villages
- Industrial wastewater
- Village sewage
- Farmland runoff
- Other non-point wastewater

Monitoring Management Treatment

Lakes
- Low Polluted Water
- Rivers

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General Thoughts on Comprehensive Treatment of Basins

How to solve this problem?
- Change lifestyle.
- Invent new technologies.
- Take new measures.

If precipitation is 1500mm/a, runoff is 70% and water consumption is 500ℓ/capital/d.

If annual discharge of P is 70%, COD is 70% and N is 50%.

Environment Limit: 150P/km²

Environment Limit: 800P/km²
A comparison among water quality of discharged domestic wastewater, lake water and river water.

Standards of water quality of discharged domestic wastewater:
- **ⅠA:** 1.0 (before)/0.5 (after)
- **ⅠB:** 1.5/1.0

Standard of water quality of rivers:
- **Ⅲ类** 0.2
- **Ⅳ类** 0.3
- **V类** 0.4

Standards of water quality of lakes and reservoirs:
- **Ⅲ类** 0.05
- **Ⅳ类** 0.1
- **V类** 0.2

Graph shows the comparison of water quality standards across different categories and time periods.
Technical System of Comprehensive Treatment

BOD
200mg/L Domestic wastewater

20mg/L Qualified effluent

5mg/L Lakes intake

<1mg/L Lake water

Wastewater treatment facilities: wastewater treatment plants, purification tanks and etc.

Eco-treatment projects: Contact Oxidation, constructed wetland and intensified purification

Eco-treatment technologies: restoration by planktons, algea, hydrophyte and others
6 major control mechanisms in restoration of ecological environmental of lakes
Restoration technologies (RS) of ecological environment of lakes

- RS in aquatic-terrestrial ecotone
  - Multi natural vegetation purification technology
  - Eco-landscape designing technology
  - Vegetation optimizing configuration technology
  - Base restoration technology

- RS of lakes water
  - Water flow control technology
  - Light control technology
  - Control technology of odor and harmful microorganisms
  - Fishing ecology control technology

- Technologies of sludge control
  - Sludge sweeping technology
  - Safe covering technology
  - Safe solidifying technology

- RS of rivers
  - Sand contact oxidation technology
  - Wetland purification technology
  - Riverbed restoration technology
  - Eco river bank technology

- RS in estuaries
  - River mouth purification technology
  - River mouth algea control technology
  - River mouth ecology restoration technology

- Technologies of blue algea control
  - Mechanical ecological algea control technology
  - Algea removing technology
  - Chemical algea-control technology
4. Work by TAES in Yuqiao Project
General Information of Yuqiao Reservoir

Luanhe-Tianjin Water Division Project started from DaHeting Reservoir in Panjiakou and went through a 12.4km tunnel and a 57.6km part of Li River, then reached Yuqiao Reservoir. The main function of Yuqiao Reservoir is water supply and flood prevention. Total capacity is 1.559 billion m³, flood prevention capacity is 1.262 billion m³, adjustment capacity is 385 million m³ and dead capacity is 360 million m³. Normal storage level is 21.16m and water area is 86.8km².
Total area of Yuqiao Reservoir watershed is 2060km², most of which is in Hebei Province. Tianjin has an area of Yuqiao Reservoir watershed of 456km², 22% of the total watershed.
According to national regulations, Yuqiao Reservoir is divided into alerting zone, first level protection zone, second level protection zone.

The alerting zone consists of 4 villages, 3000 people and 153km² area.

The first level protection zone is 33km² and consists of 44 villages with 43 thousand people.

The second level protection zone is 260km² and consists of 135 villages with 102 thousand people.
Eutrophication of Yuqiao Reservoir

• According to regulations and standards of China, water quality of Yuqiao Reservoir should be kept above III level.
• Based on investigation result from 1983-2008, TN is much more than normal standard. TN is IV level before 2005, and V after 2005. TP is just around the normal standards.
• Now, Yuqiao Reservoir is in light entrophication.
Because of eutrophication and hydrology condition, algae growth year by year.

Good weed: Jucao

Many dead weeds will damage the quality of Luanhe River. The weeds will also release nutrient for algae growth. Many weed were collected manually in 2006, 2007, 2008.
Analysis of pollution in Yuqiao Reservoir

Analysis of pollution source

- Water from Luanhe River
- Three rivers go into the reservoir
- Activities around the reservoir

Eutrophication of Yuqiao Reservoir

Nutrient release after long time accumulation

Outer source: mainly provide N
Inner source: mainly provide P

TN load from inner and outer source 93.5%
TP load from inner and outer source 6.5%
Analysis of pollution in Yuqiao Reservoir

Analysis of Outer pollution source

TN load of three rivers

- 沙河 38.4%
- 聊河 54.7%
- 引滦来水 1.9%

TP load of three rivers

- 沙河 22.6%
- 聊河 5%
- 引滦来水 2.5%

Main source for Li River
Mineral mountain, agricultural runoff, rural life

Way of combination
Most pollution combines through 9 subrivers at the mouth of Li River, 4 of which consist 80% of total water amount.

Main source: solid waste, agricultural non-point pollution, rural sewage, mountain runoff
Way of combination: together with surface runoff and through tunnels around reservoirs and end in reservoir
Analysis of inner pollution source

**Accumulation for long years:** In many years, input nutrient is more than output, most of nutrient stays in the reservoir (TN: 64.5%、TP: 70%).

**Optional release:** In proper temperature, PH, turbulence and hydrophyte, P can be released by 144ton/year.

Inner nutrient source is mainly from waterweed, which contains a N and P of 74% and 94% respectively.

During the growth of weed, it can help transfer inner pollution and purify the water. After the dead of weed, it will release the nutrient and pollute the water.
Our Recent Work

- Temperature
- Topography
- Soil
- Stormwater
- Vegetation

- Farming
- Raizing
- Life
- Fishing
- Recreation

- Immigration

- Improved model of SWAT

- Distribution of rural pollution load
- Self purification capacity factor
- Limits by economy and society

- Pollution load factor
Our Recent Work

Classification of non-pollution sensitive area in Yuqiao Reservoir
Our Recent Work

Safe Drinking Water for Sustainable Cities in China: Source Water Protection for Tianjin

Submitted to:
United States Environmental Protection Agency (USEPA)

Submitted by:
Civil Engineering Research Foundation (CERF)

December 2006

Feasibility Study of Comprehensive Village Waste Management in the Yuqiao Reservoir area, Tianjin, China

Prepared by:
Tianjin Environmental Protection Bureau
Tianjin Academy of Environmental Sciences

November 2005

2003-2006 2006-2008

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近期开展的工作

CVMP comprehensive village waste management plan

- rural life
- garbage
- faeces
- dumping site
- refuse treatment plant
- residue from biogas tank
- fish culture
- organic fertilizer
- livestock
- animal waste
- feed
- fermentation
- composting
- straw return
- crop straw
- Farmland

Straw return to farmland for crop straw production.
Experiment Description

We chose seven programs with different nutrients input for field crops, and kept sampling surface runoff and soil of these programs in rainy season in order to measure nutrient load from the loss of surface runoff. Through comparison of crop yield in different programs, it is possible for us to determine the most optimal planting program for the village which could provide support for the CVMP.

Design of Runoff Pond

Structure of runoff pond  Design rendering  Effect of actual construction
Runoff Experiment

- Plowing
- Sowing
- Discussion of nutrient ratio
- Fertilizing
- Sampling runoff
- Sampling soil

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Experiment Description

Separately stack the manure of livestock and farmland soil of Dajugezhuang. The composting cycle is 70 days, sample soil and fertilizer once every 5 days, record weight, environmental temperature, relative humidity, surface wind speed. At last, we intend to build a proper soil and fertilizer nutrients loss model based on the residual nutrients in samples and meteorological data.

Stacking soil and fertilizer

Sampling soil  Delivering  Weighing  Composting

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Vi trenger dine forslag ...

Takk