

# **Harmful Algae and Associated Taste & Odor Problems in Source Water**

**Min Yang**

**Research Center for Eco-Environmental Sciences,  
Chinese Academy of Sciences**



# Outline

Backgrounds

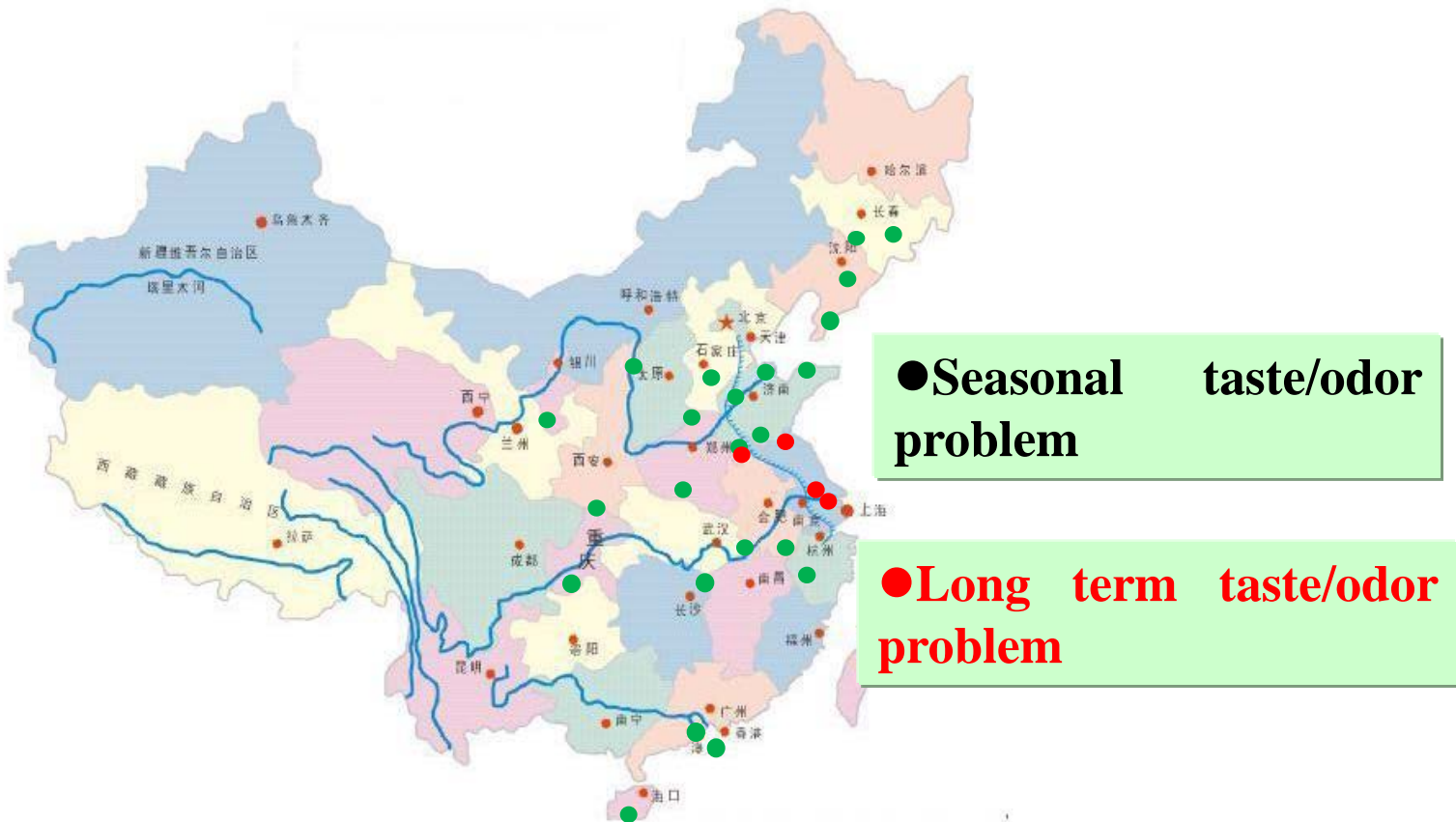
Approaches

Case studies

Conclusion

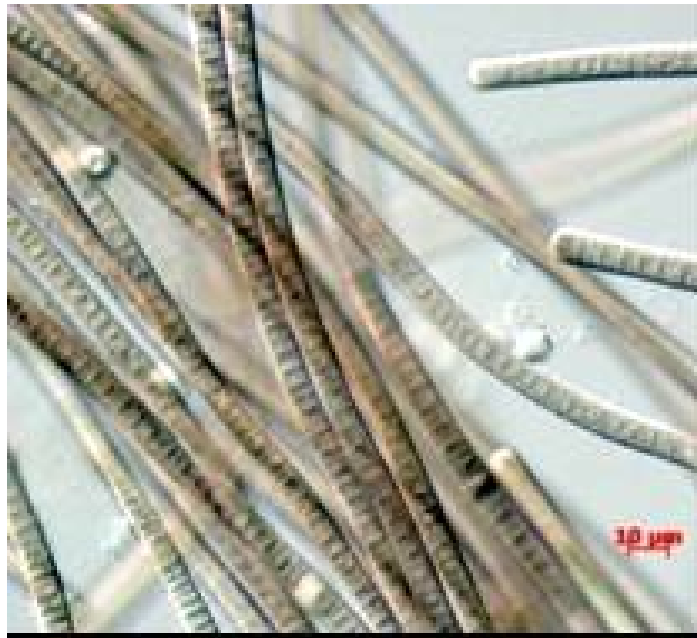
# BACKGROUNDS

- **Taste/odor problems due to algal growth occur frequently in China.**

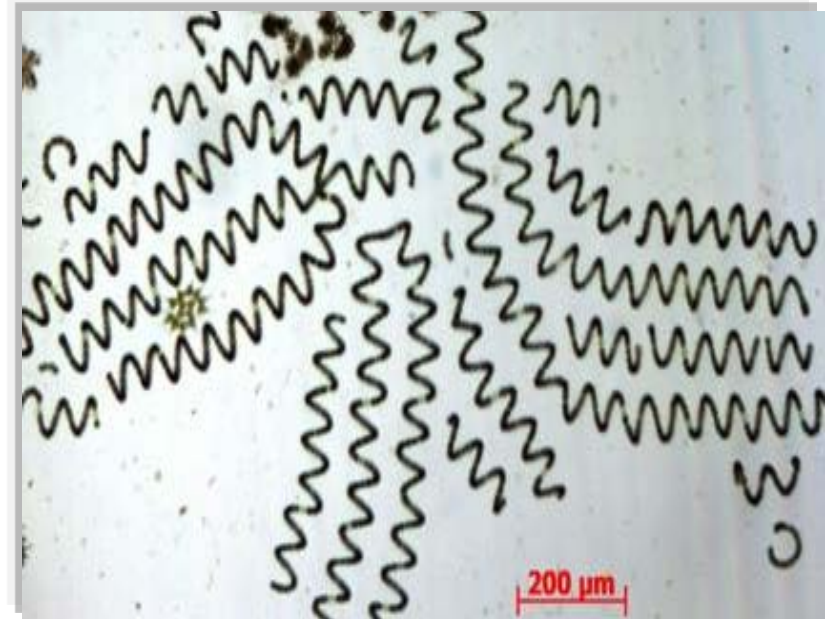


# BACKGROUNDS

- Different T/O problems arise from different algal metabolites.
- MIB is mainly produced by *Phormidium* / *Oscillatoria* while geosmin is produced by *Anabaena*.

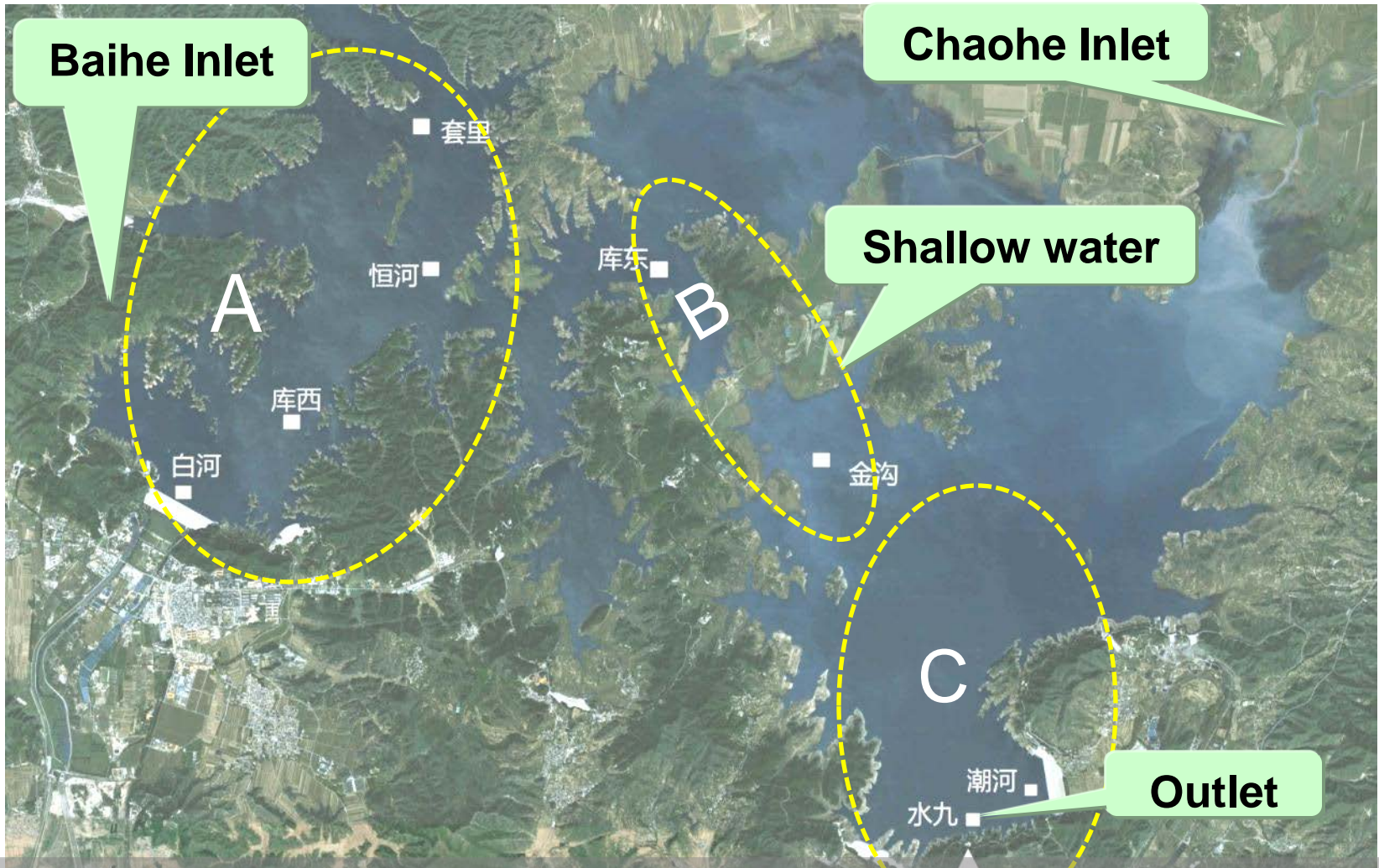


MIB producing  
*Phormidium* sp.



Geosmin producing  
*Anabaena spiroides*

# Miyun Reservoir



**Max. capacity: 4.3 bil m<sup>3</sup>, actual volume: 0.8-1.1 bil m<sup>3</sup>**

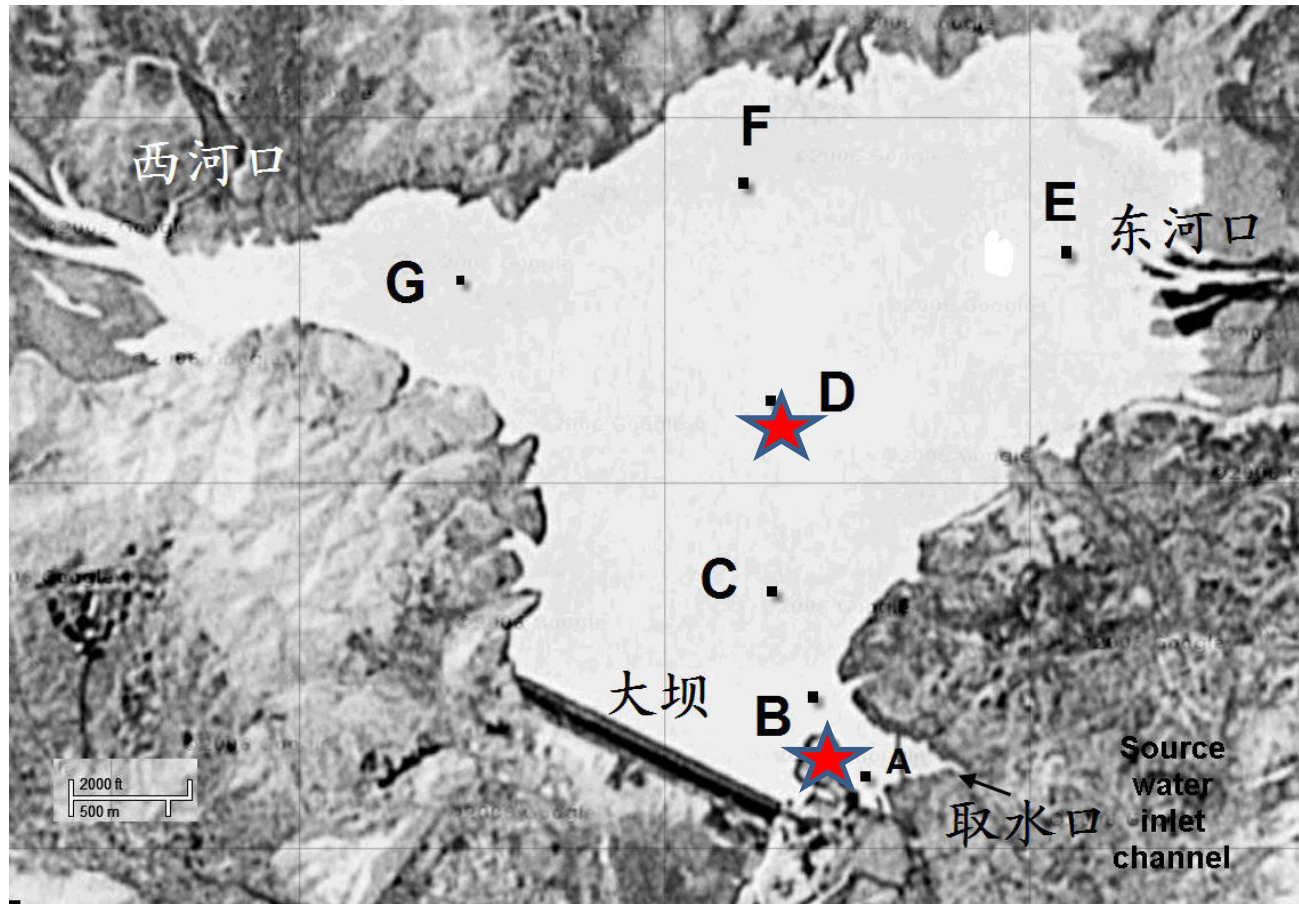
# Algal community structure

Phyta	Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	<i>Asterionella</i>	3	2	1	1	1	1	1	1
	<i>Cyclotella</i>	3		1	1	1	1	1	1
Diatom	<i>Fragilaria</i>	3		1	1	1	1	1	1
	<i>Synedra</i>	4		2	1	1	1	2	4
	<i>Melosira</i>	4		2	1	1	1	2	1
Chryso	<i>Dinobryon</i>	2		4	0	0	0	0	0
	<i>Microcystis</i>	0	1	2	4	4	4	4	2
Cyano	<i>Osc/Pho</i>	0	0	1	1	1	3	1	1
	<i>Planktonthrix</i>	0	0	1	1	1	1	1	0
	<i>Chlorella</i>	0	0	1	3	1	1	1	1
	<i>Secendesmus</i>	2	2	1	2	1	1	1	1
	<i>Pediastrum</i>	2	2	2	2	1	1	1	1
	<i>Gloeotidium</i>	1	1	1	2	1	1	1	1

• Cyanobacteria dominant from July to Oct with a low algal diversity.

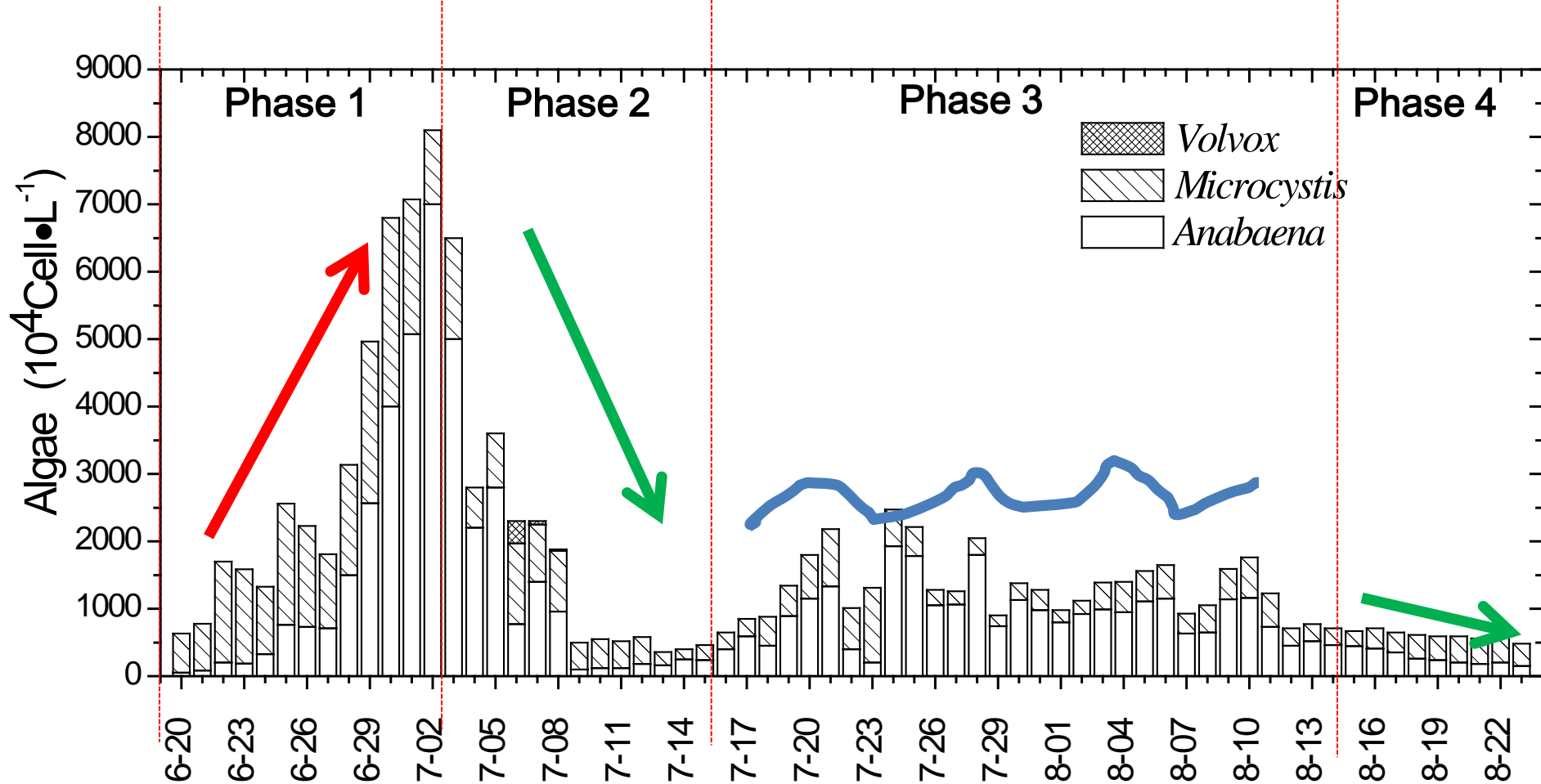
• *Phormidium/Oscillatoria* density increased in Sep. & Oct.

# YH Reservoir



- Capacity: 0.35 billion  $m^3$ ; average vol: 75  $Mm^3$ ; water area: 13  $km^2$ ; average depth: 5.7 m.
- **Heavy odor event occurred from June to Aug. in 2007**

# Algal Dynamics (2007)



*Anabaena* was the dominant species at peak time.



# The scientific problem

- ✳ **Why do different algal species grow in different water bodies?**
- ✳ **Can we predict the growth of odor-causing algae?**



- **Characterization of source water across China (T/O, water quality, algal diversity/species, etc.).**
- **Continuous monitoring (Miyun, Yanghe, Laohutan, etc.)**
- **Identification of new T/O compounds and related algae.**
- **Prediction of specific algal growth based on model simulation.**

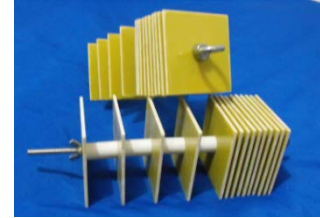
# Sampling across China



•34 major cities

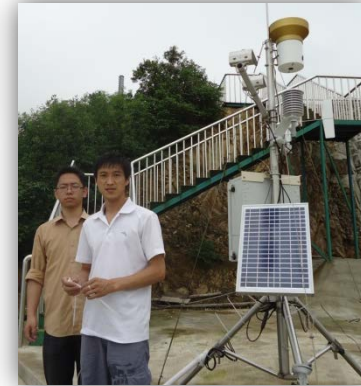
# Sample collection and storage

- Algae
  - Benthic, plates for algal growth
  - Phytoplankton, plankton net
  - Logus' solution
- Taste & odor
  - Vertical (multi-layer)
  - Critical position
- Water quality



# Monitoring

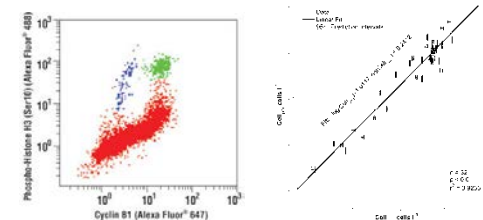
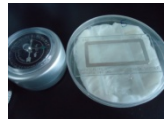
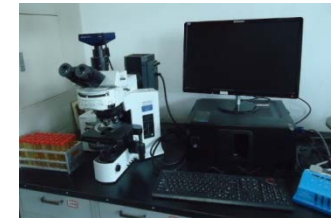
- **Weather station**
  - Wind, rainfall, radiation, temperature, relative humidity, etc.
- **Water quality**
  - YSI (Temperature, pH, chlorophyll, turbidity, conductivity, orp, etc.)
- **Terrain**
  - ADCP (bottom track)



2009 07 22 15 54

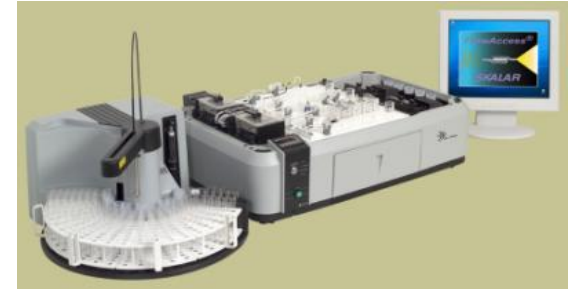
# Algal population

- Identification
  - Microscope (Experience/Books/Google/Previous research/Algal database)
  - Molecular (DGGE, clone library)
- Quantification
  - Microscopic counting
  - Flow cytometry
  - Real-time PCR



# Water quality parameters

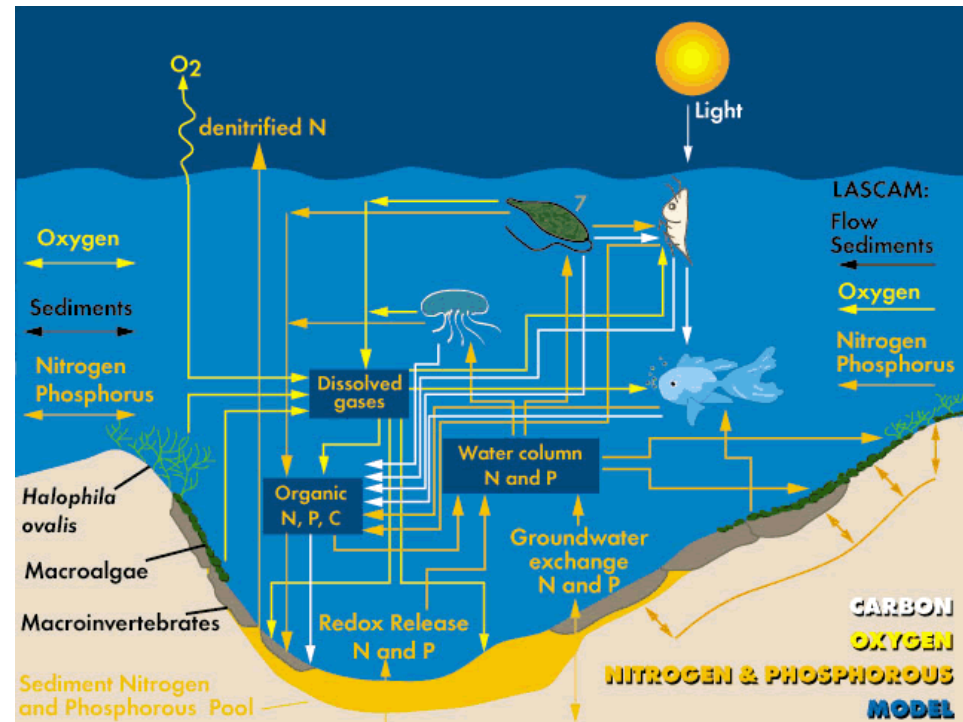
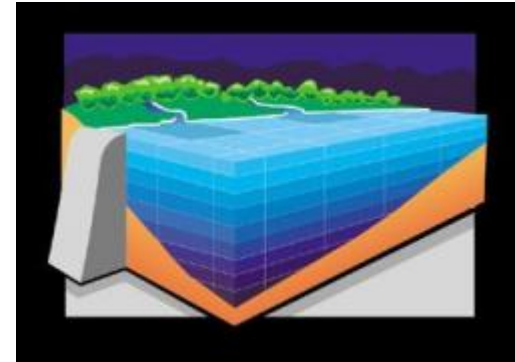
- T/O compound analysis Sensory GC (identification)  
SMPE-GC/MS (quantification)  
q-PCR based on functional genes
- Nutrient
  - $\text{NH}_4\text{-N}$ ,  $\text{NO}_3\text{-N}$ ,  $\text{NO}_2\text{-N}$ , TN,  $\text{PO}_4\text{-P}$ , TP, etc.
- Other
  - Chlorophyll a, TOC, etc.



# Modeling (ELCOM - CAEDYM)

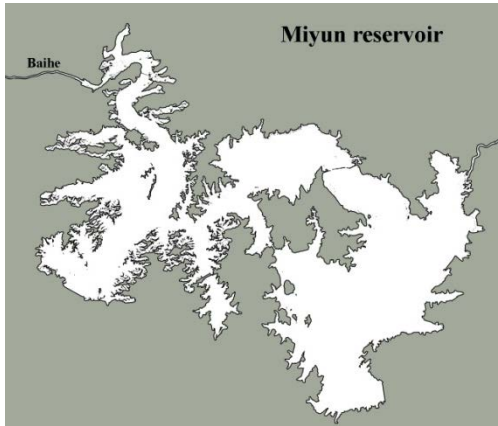
ELCOM (Estuary and Lake Computer Model) is a three-dimensional hydrodynamics model used for predicting the velocity, temperature and salinity distribution in natural water bodies subjected to external environmental forcing such as wind stress, surface heating or cooling.

The Computational Aquatic Ecosystem Dynamics Model (CAEDYM) is an aquatic ecological model that may be run independently or coupled with hydrodynamic models DYRESM or ELCOM. CAEDYM consists of a series of mathematical equations representing the major biogeochemical processes influencing water quality

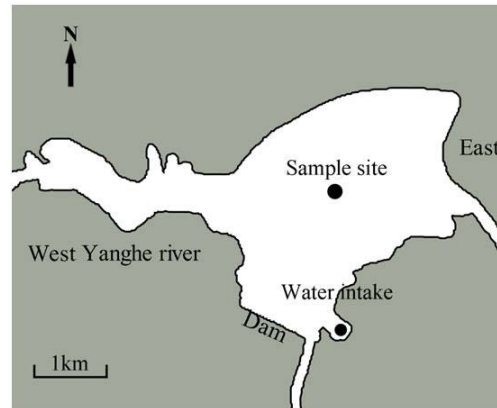


# CASE STUDIES

## Miyun Reservoir



## Yanghe Reservoir



## Laohutan Reservoir

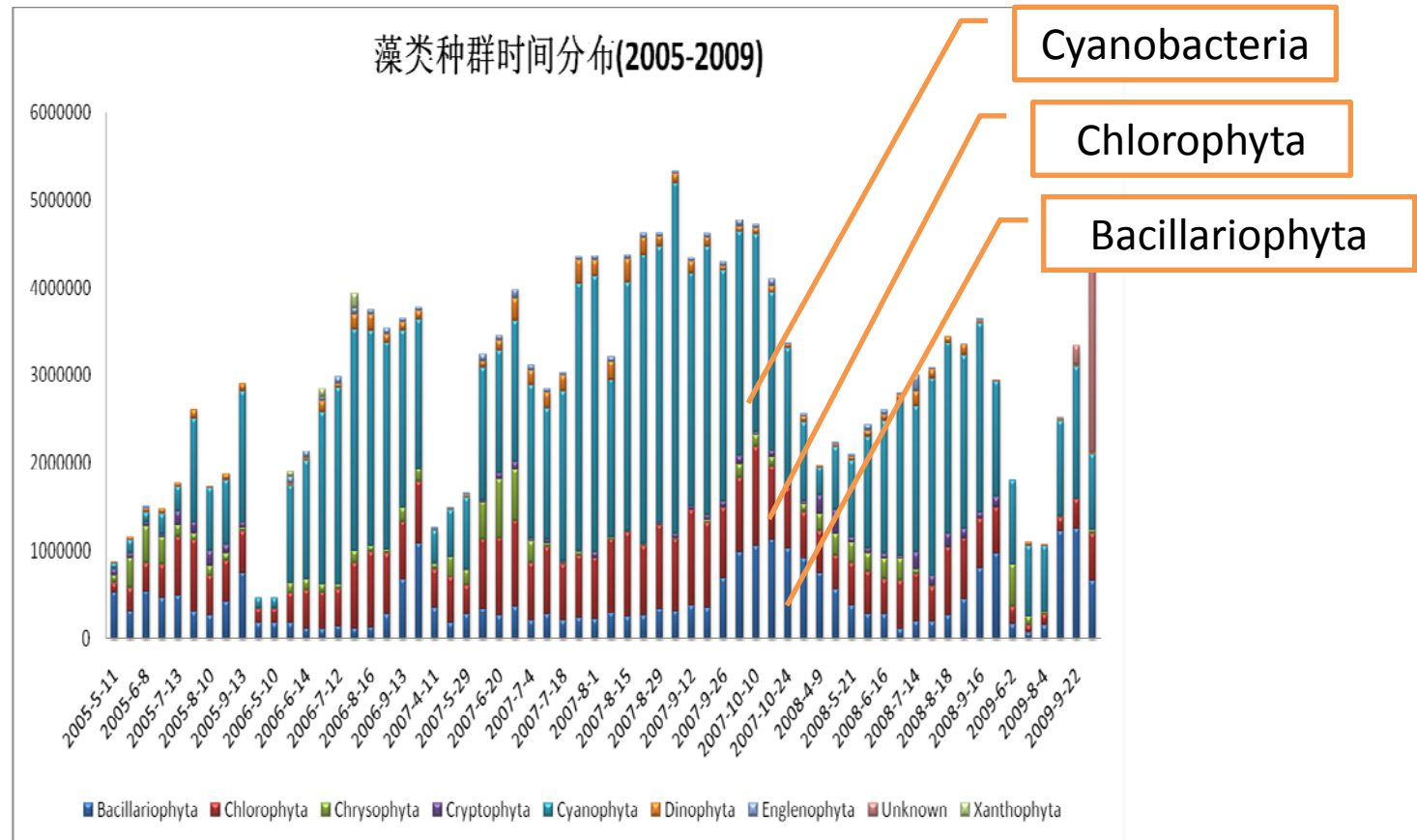


	Capacity	Max depth	Average depth	Problem
<b>Miyun</b>	4.37 billion m <sup>3</sup>	43.5m	8-10m/20-30m	MIB (Oscillatoria/Phormidium)
<b>Yanghe</b>	358 million m <sup>3</sup>	12m	4-6m	geosmin(Anabaena) MCs(Microcystis)
<b>Laohutan</b>	100 million m <sup>3</sup>	30m	8-12m	algal bloom, fishy



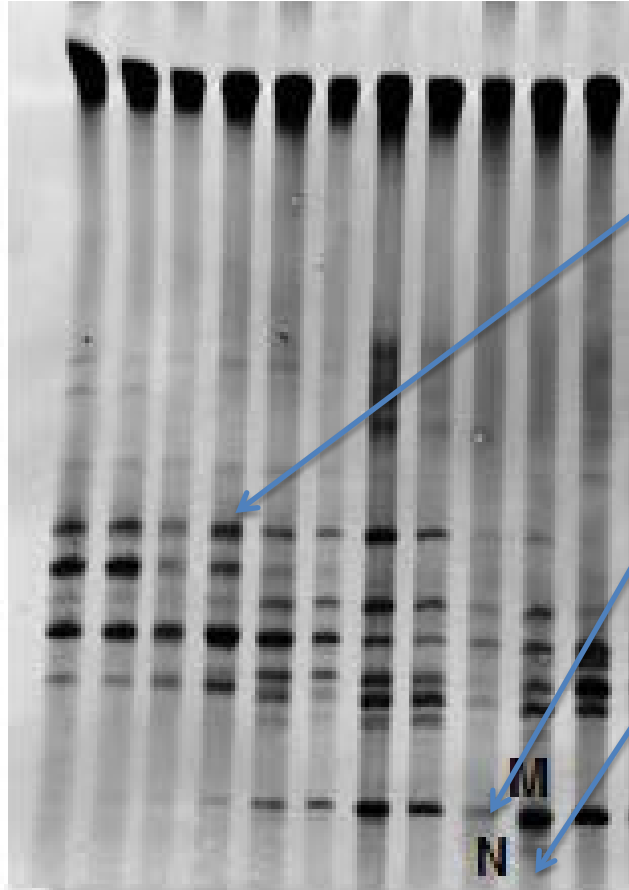


# Temporal variations of algae



- i. The highest algal density came out during Aug. to Oct;
- ii. The abundance of Bacillariophyta is high during Nov. to May;
- iii. Cyanobacteria was the dominance algae during summer and autumn;
- iv. Chlorophyta grew quickly at the end of spring and beginning of summer.

# ITS-DGGE

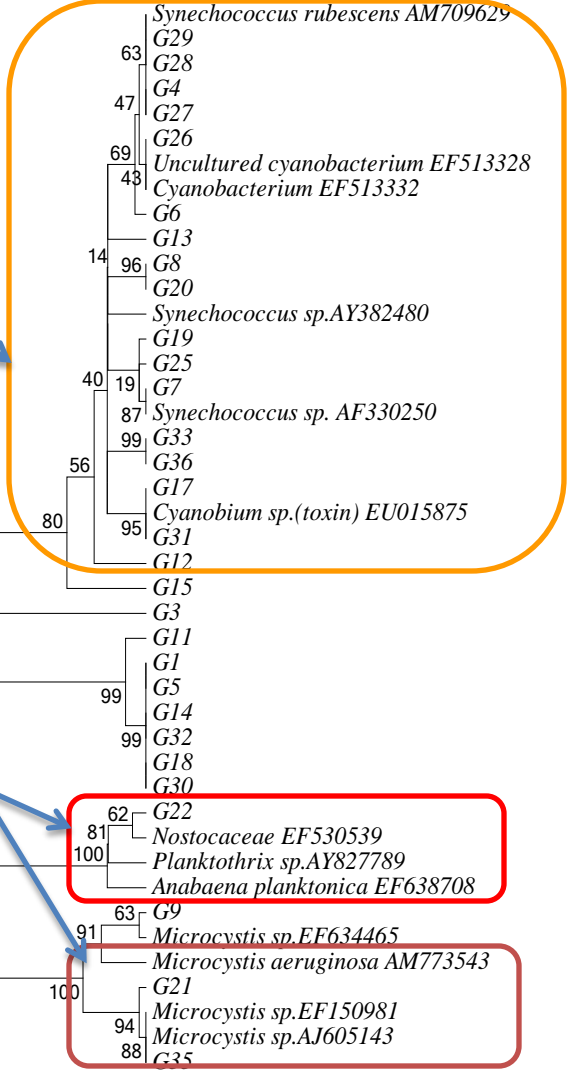


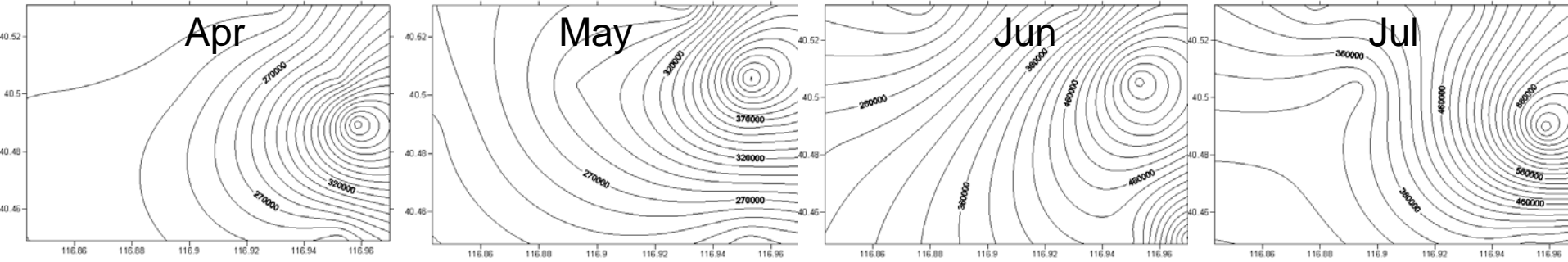
5 6 7 8 9 10

*Syrechococcus*  
*cus* sp.

*Microcystis*

*Pho./Osc.*

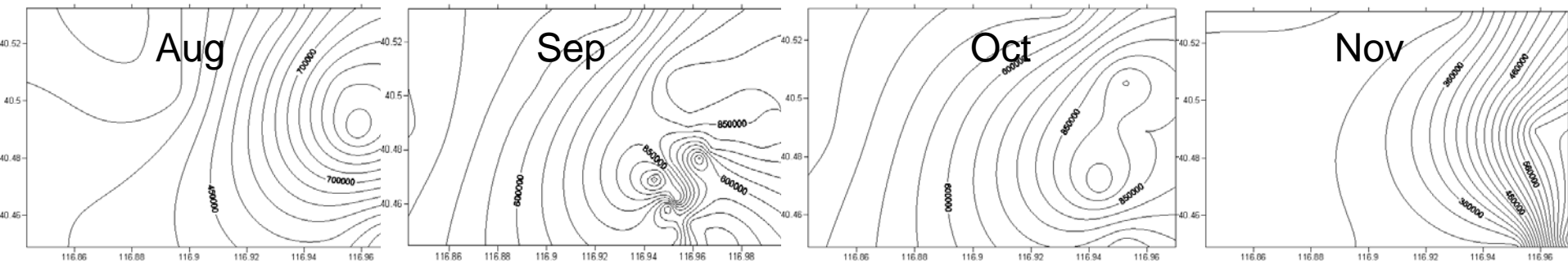
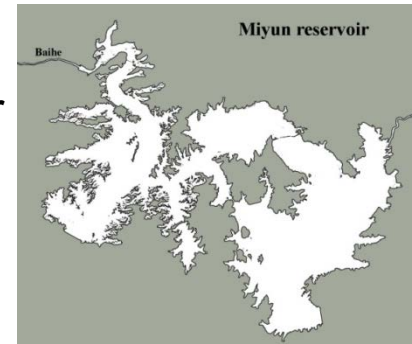




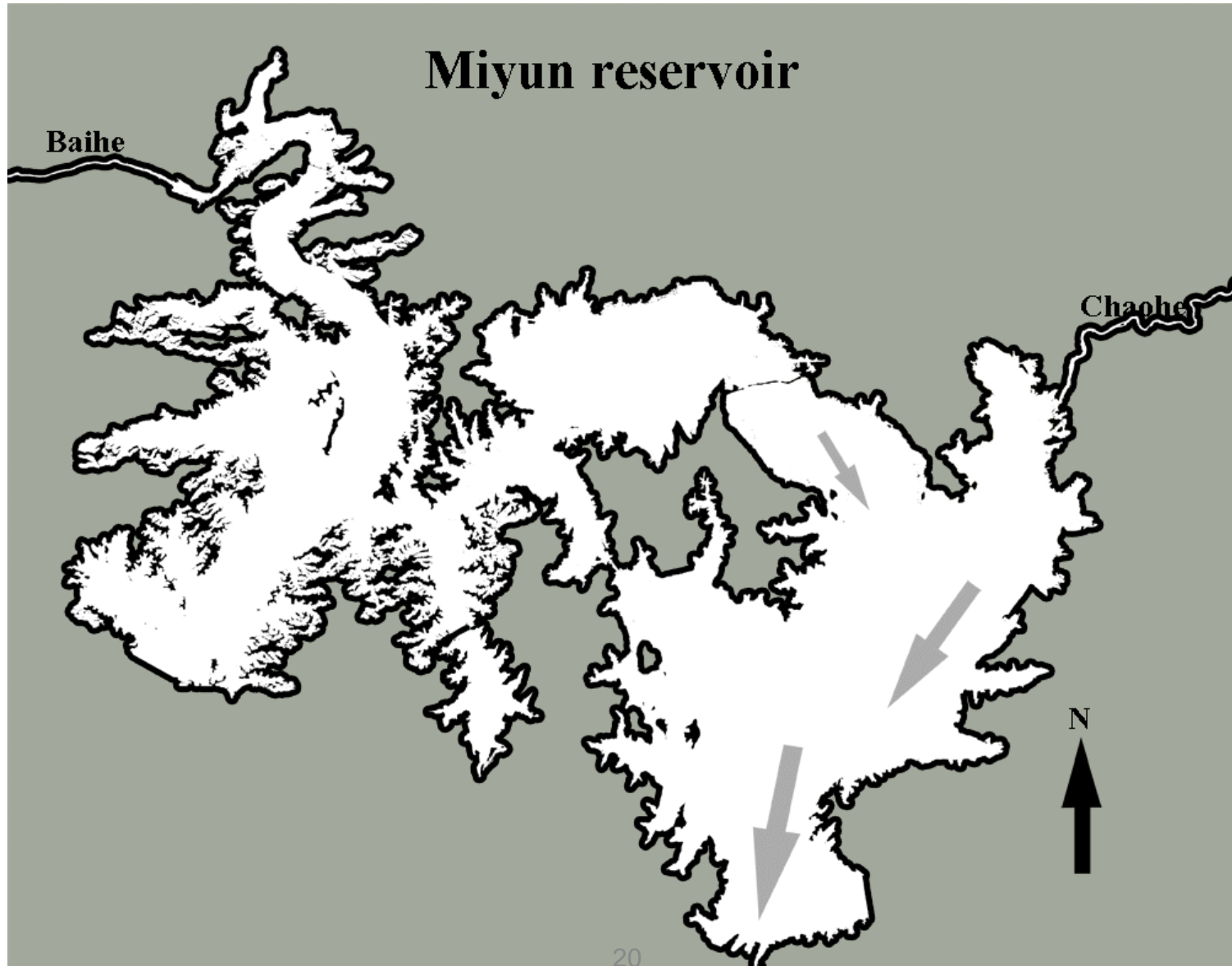
# Spatial – temporal distribution of algae species in Miyun reservoir, 2009.

- i. Algal was distributed at the east part of reservoir;
- ii. The center of the algal distribution center moved south from north during Aug to Nov.
- iii. The algae density decreased in Oct, and the distribution center disappeared in Nov.

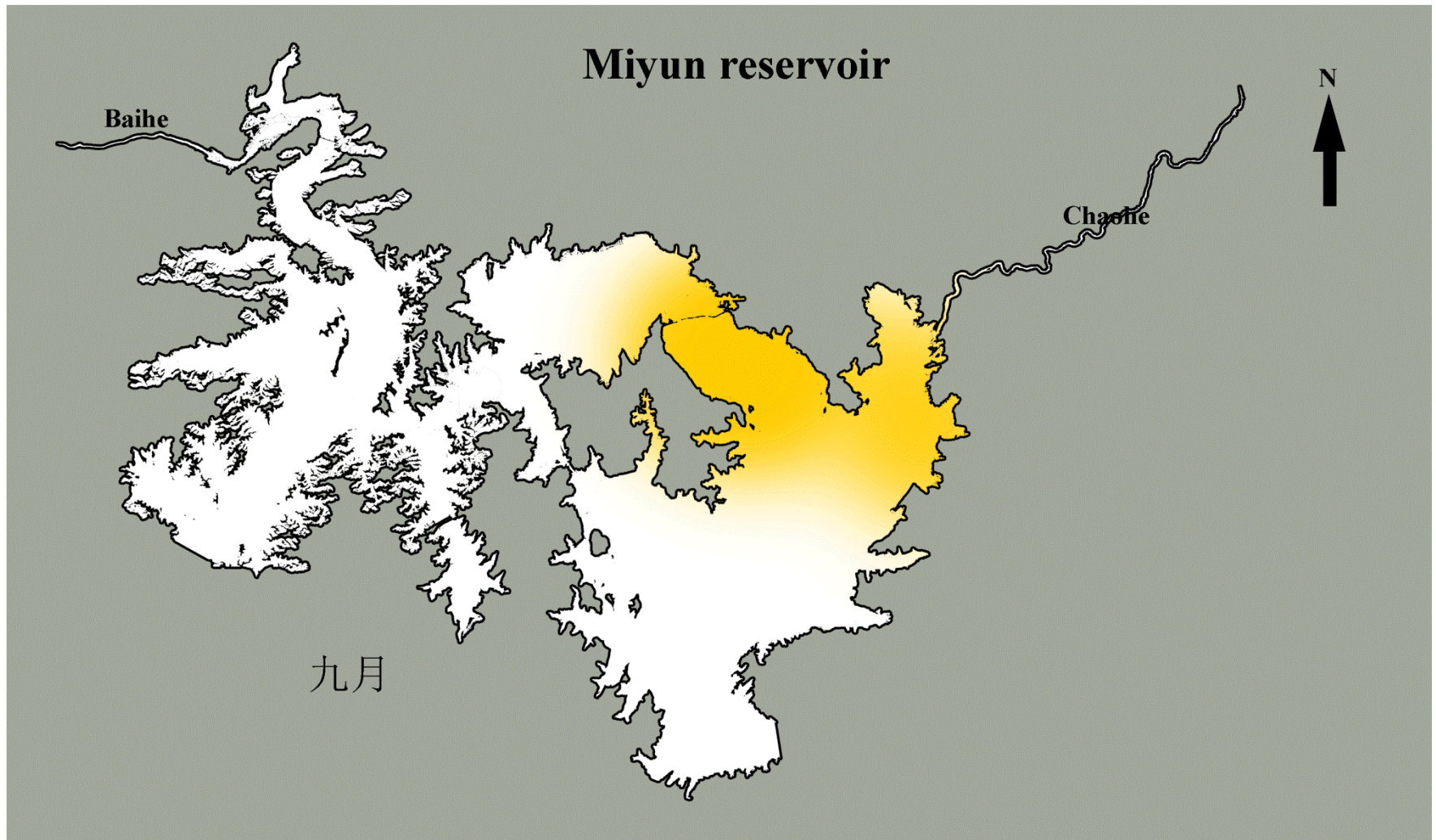
The reason for this are mainly caused by the reservoir terrain and weather in Beijing (wind direction).



# Nutrient and flow characteristic



# MIB distribution



# Conclusions

- **MIB occurs more frequently in source water of major cities across China.**
- **High algal diversity with seasonal variations was observed in Miyun;**
- **Cyanobacteria was the dominant phyta (e.g. *Microcystis*) in the period between July and October, and preferential growth of *Oscillatoria* and *Phormidium* was observed in September and October, causing the MIB problem.**



# Thank you!

**Thanks for the support from**

- **NSFC**
- **Beijing MiYun Reservoir Administration Office**
- **CAS**