中國環境科學研究院
Chinese Research Academy of Environmental Sciences

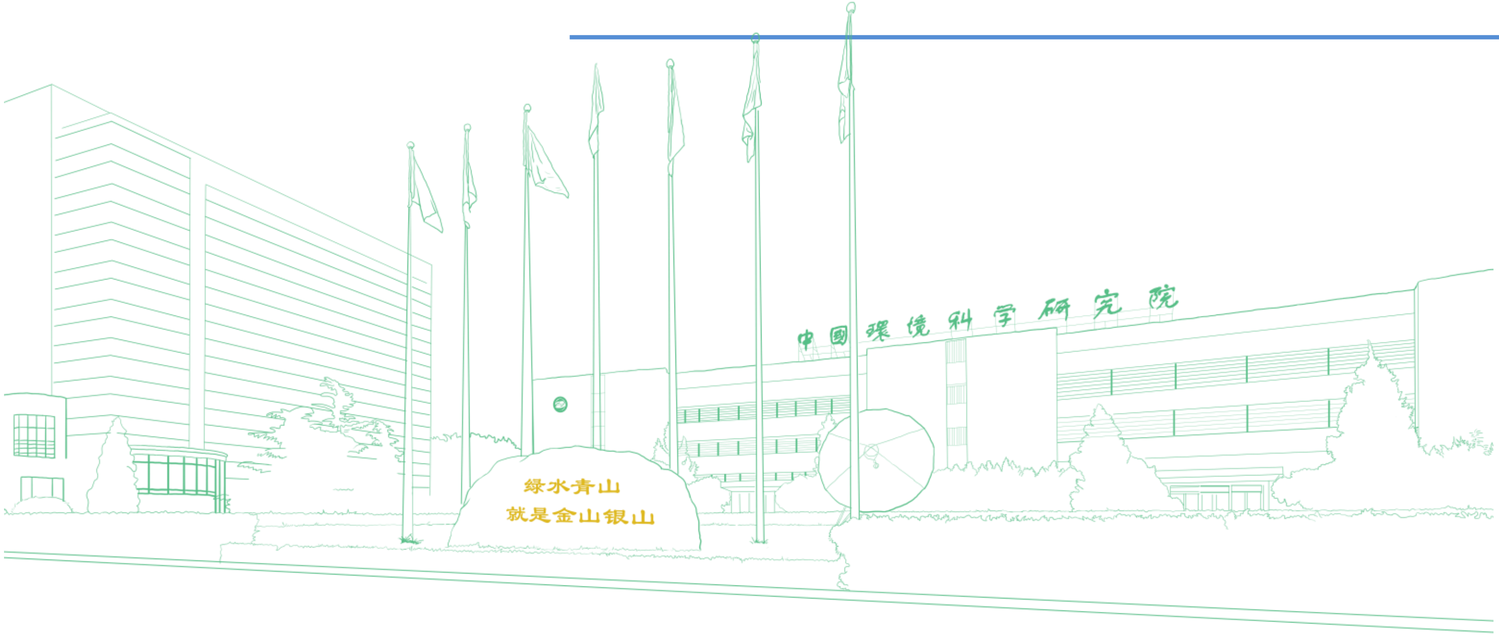
Investigation and assessment of freshwater ecosystem quality in the Taitema Lake

Chinese Research Academy of Environmental Sciences

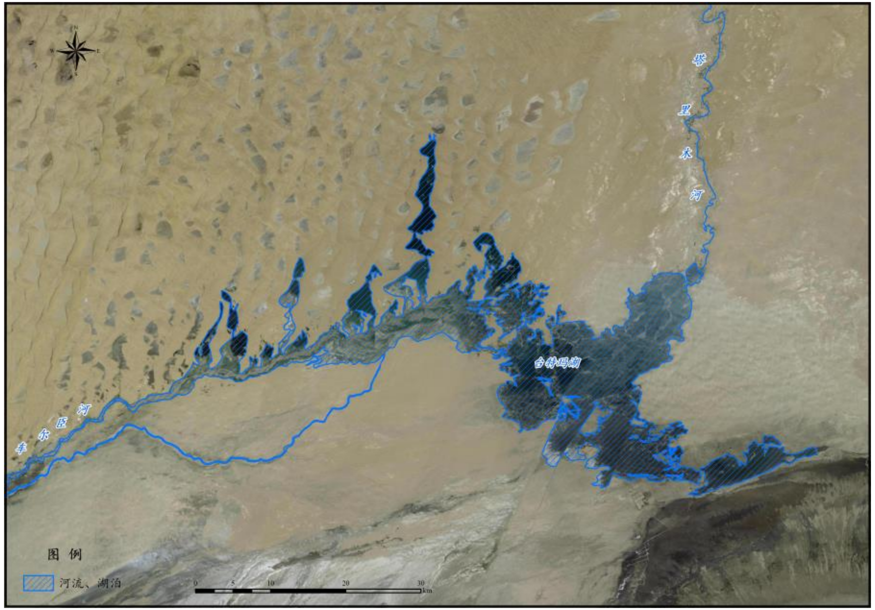
Weijing Kong

Outline of the report

1 Overview of the region



1.1 Overview of the region



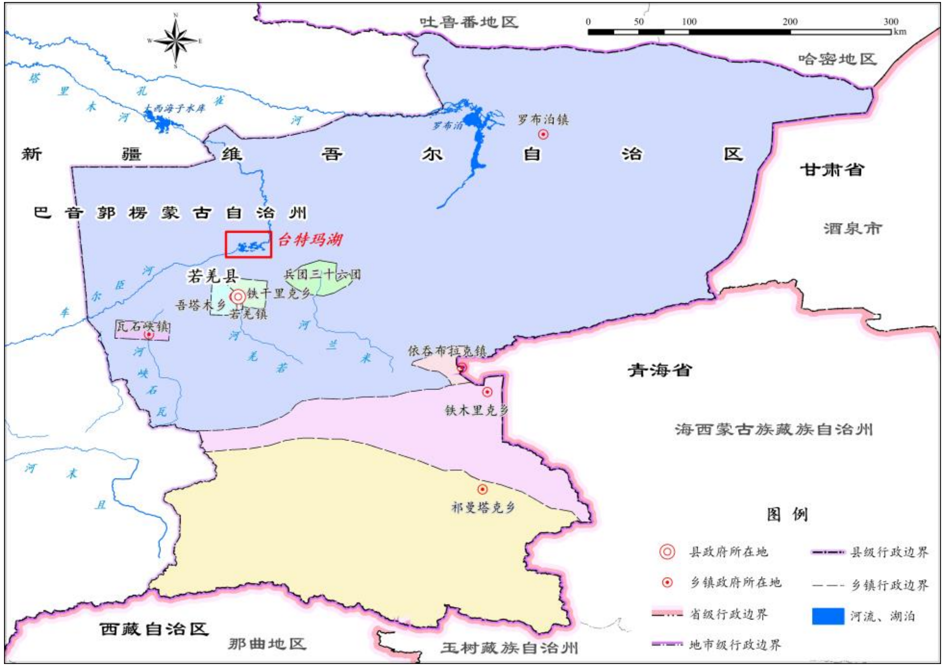
- With an area of about **200 square kilometers**, Taitma Lake is the **terminal Lake** of the Tarim River, the largest inland river in China;
- It is one of the most important ecological barriers in Ruoqiang County, preventing the convergence of the **Taklamakan Desert and the Kumtag Desert**；
- The Lake Taitma area includes Lake Taitma, the Lake Conlac group and their surrounding vegetation areas, with a total area of **1998 km²**；
- After 1972 it dried up, ecological water transfer began in 2000, and now the surface of Lake Taitma has been restored.

1.1 Overview of the region

- Ruoqiang County is a county under the jurisdiction of Bayingolin Mongolian Autonomous Prefecture, located in the southeast of Bayingolin Mongolia, with an area of **202,300 km²**, which is the largest county in China. In 2020, the registered population is 80,700 and the GDP is 5.829 billion yuan.

- Ruoqiang County has a warm temperate continental desert arid climate, with an annual average temperature of 11.8° C, an average annual precipitation of 28.5mm, and an evaporation of more than 3000mm ;

- The main rivers are: Ruoqiang River, Cherchen River, Tarim River and other 14 inland rivers. The total annual runoff is 1.176 billion m³.



1.2 Project background

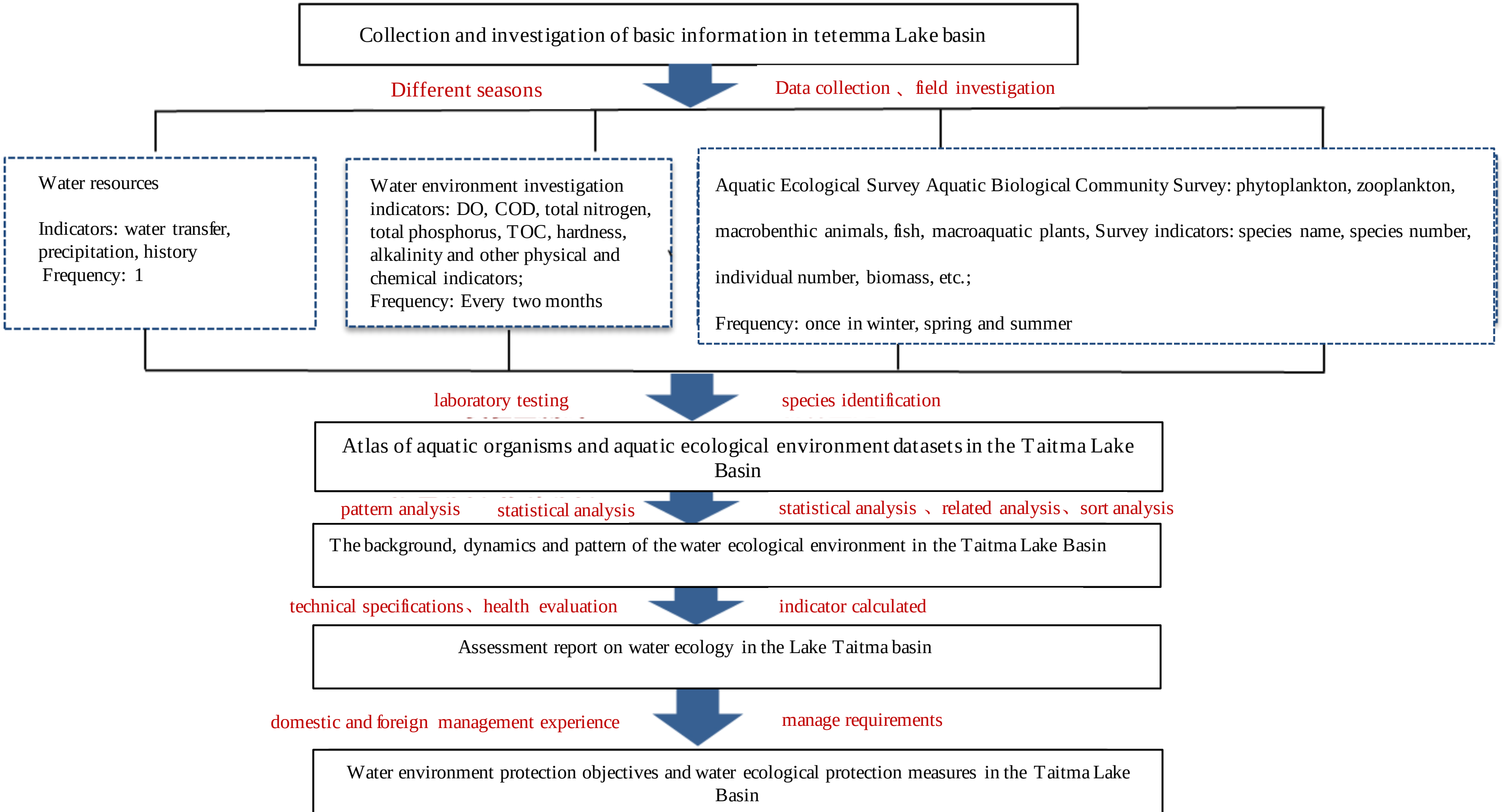
The necessarity of freshwater ecological investigation and evaluation

- China is currently in an important stage of freshwater management: "pollution discharge control - water quality improvement - freshwater ecosystem management" ;
- The **14th Five-Year Plan** for the main basins has added freshwater ecological indicators, and the implementation of the project has provided technical support for the assessment of the freshwater ecological environment of Xinjiang lakes.
- Freshwater ecological investigation is an important way for evaluating the conservation effectiveness of Lake Taitema and carrying out the ecological restoration of Lake Taitema.

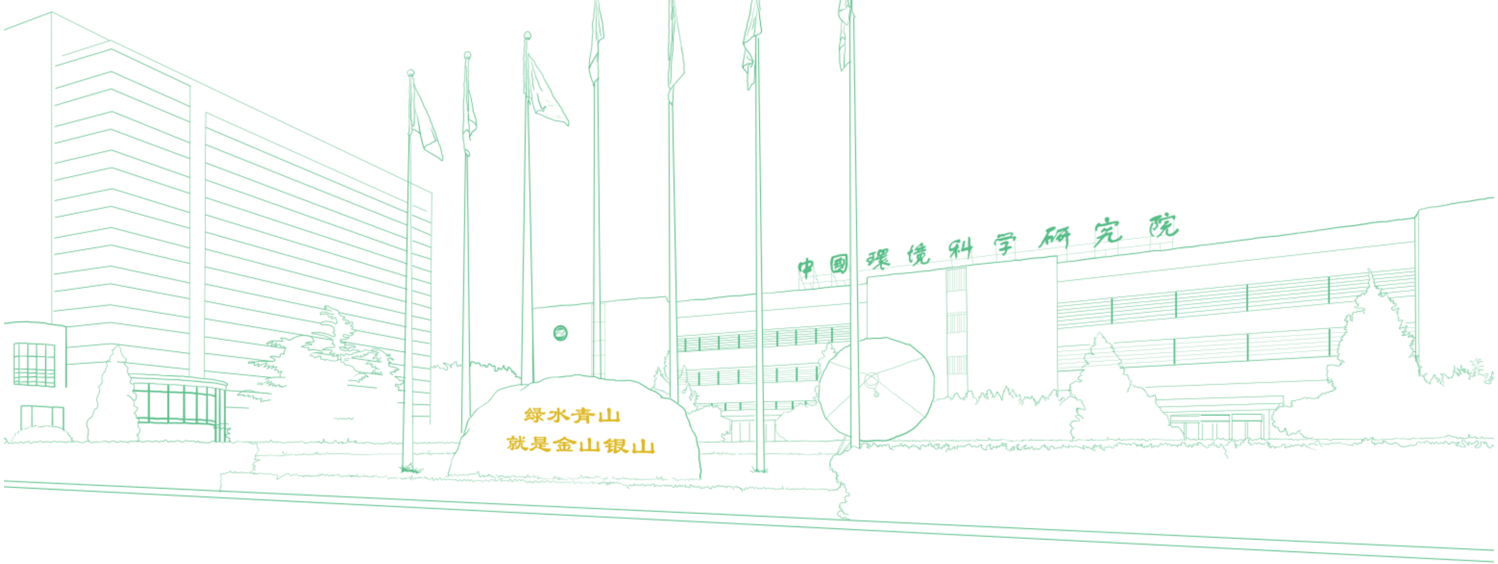
Advantages of freshwater ecological investigation and evaluation

- Relying solely on physical and chemical indicators of water has limitations in the evaluation of water environmental quality.
- The results of aquatic biological evaluation can characterize the compounding and cumulative nature of environmental pollution.
- It can reflect the **combined environmental pressures of water pollution, water resources and habitat destruction**.

1.3 Technical Route



2 Evolution of water resources



2.1 Water resources - the transport of water from the Tarim River to Lake Taitma

- Since the implementation of the ecological water conveyance project in the lower reaches of the Tarim River in 2000, the ecological water discharged from the Daxihaizi Reservoir has been carried out 23 times, with a total amount of more than 87.45 × 10^8 m^3, of which the total amount of groundwater recharged through river infiltration is about 30.6 × 10^8 m^3, and the amount of water entering the terminal Taitma Lake is about 11.7 × 10^8 m^3, accounting for about 13.80% of the total water transferred.

- In August 2021, 348 million m^3 of water was transported downstream by the through-discharge of Tarim River, and the ecological governance effect of the lower Tarim River was consolidated.

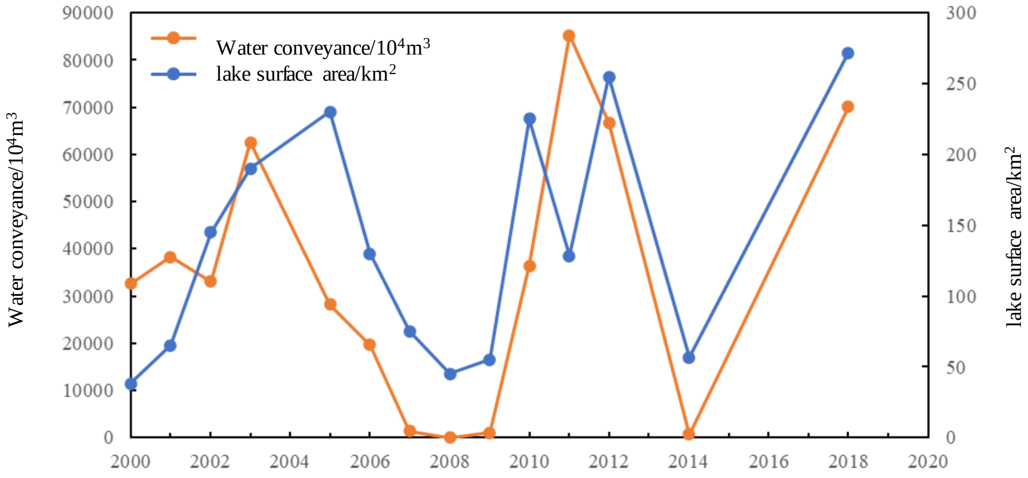
Number of water transfers	Date of delivery	The downward flow of Daxihaizi Reservoir/Million cubic meters	Destination
the 1st time	2000/5/14 - 7/12	9923	Kordai
the 2st time	2000/5/14/- 12/31	22655	30km below Arakan
the 3st time	2001/4/1 - 11/18	38223	Taitma Lake
the 4st time	2002/7/20/ - 11/10/	33129	Taitma Lake
the 5st time	2003/3/03/ - 11/3/	62509	Taitma Lake
the 6st time	2004/4/23/ - 6/22/	10207	Taitma Lake
the 7st time	2005/4/18/ - 11/2/	28272	Taitma Lake
the 8st time	2006/9/25/ - 11/21/	19644	Kaukan
the 9st time	2007/10/10/-10/21/	1410	Kordai
the 10st time	2009/12/5/ - 12/31/	1066	Kordai
the 11st time	2010/6/25/ - 11/11/	36393	Taitma Lake
the 12st time	2011/1/07/ - 11/23/	85211	Taitma Lake
the 13st time	2012/4/27/ - 11/27/	66716	Taitma Lake
the 14st time	2013/4/25/ - 11/5/	48769	Taitma Lake
the 15st time	2014/6/17/ - 6/26/	727	172km below Daxihaizi Reservoir
the 16st time	2015/8/18/ - 11/5/	46218	Taitma Lake
the 17st time	2016/8/11/ - 10/31/	67611	Taitma Lake
the 18st time	2017/4/27/ - 12/31/	121461	Taitma Lake
the 19st time	2018/2/26/ - 11/21/	70006	Taitma Lake
the 20st time	2019/8/11/ - 12/31/	46352	Taitma Lake
the 21st time	2020/09/5/ - 12/31/	28084	Taitma Lake
the 22st time	2021/8/2/-11/11/	34800	Taitma Lake

2.2 Water resources - changes in the area of Lake Taitma

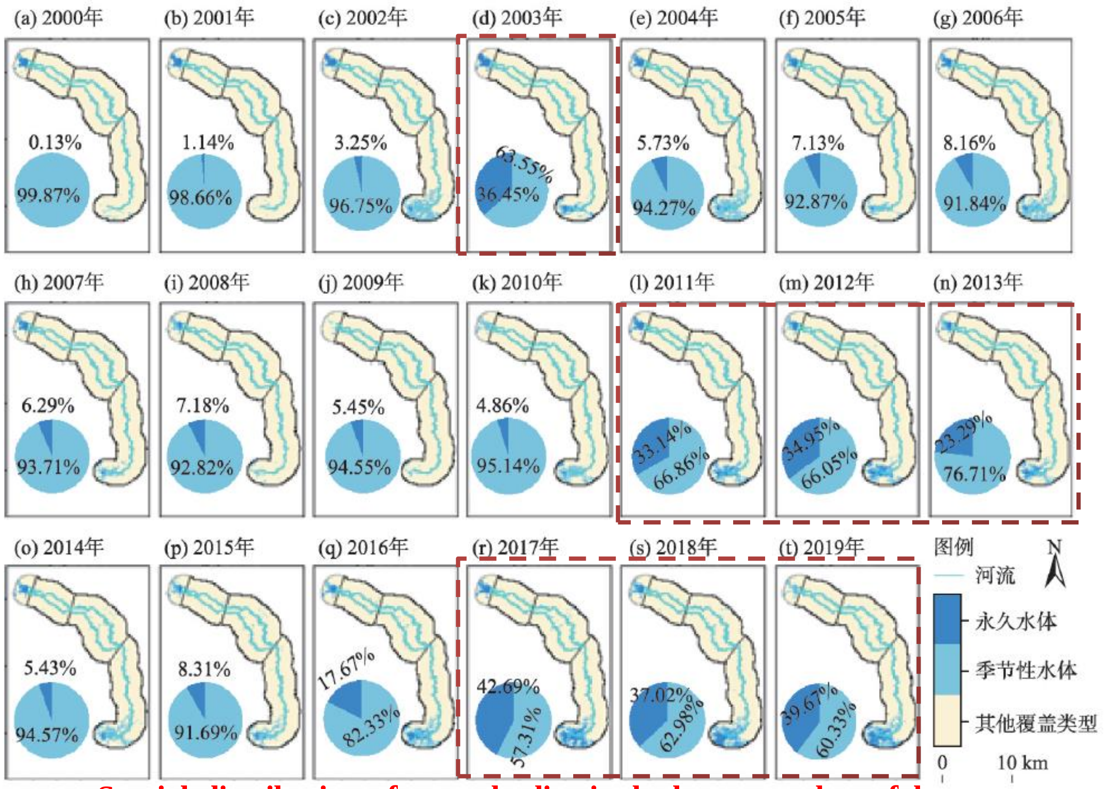
- From 2000 to 2019, the area of surface water, seasonal water bodies and permanent water bodies in the lower reaches of the Tarim River showed a fluctuating upward trend. The water transmission project in the lower reaches of the Tarim River is the dominant factor in the change of water area.

- The main factor affecting the area of Lake Taitma is not the total amount of water replenished each year, but that it is greater than a certain flow threshold and has a certain duration of time.

Year	Change in water area /km²	R/%	Rs/%
1986-1991	11.11	80.87	16.17
1991-1994	-16.02	-64.44	-21.48
1994-1998	5.09	57.65	14.41
1998-2002	65.32	468.88	117.22
2002-2007	-3.93	-4.95	-0.99
2007-2011	53.07	70.46	17.61
2011-2015	-47.54	-37.02	-9.26
2015-2019	96.82	119.75	29.94
1986年-2019年	163.93	1193	36.15



2.3 Water resources – the amount of ecological water transported has a decisive influence on the area of Lake Taitma

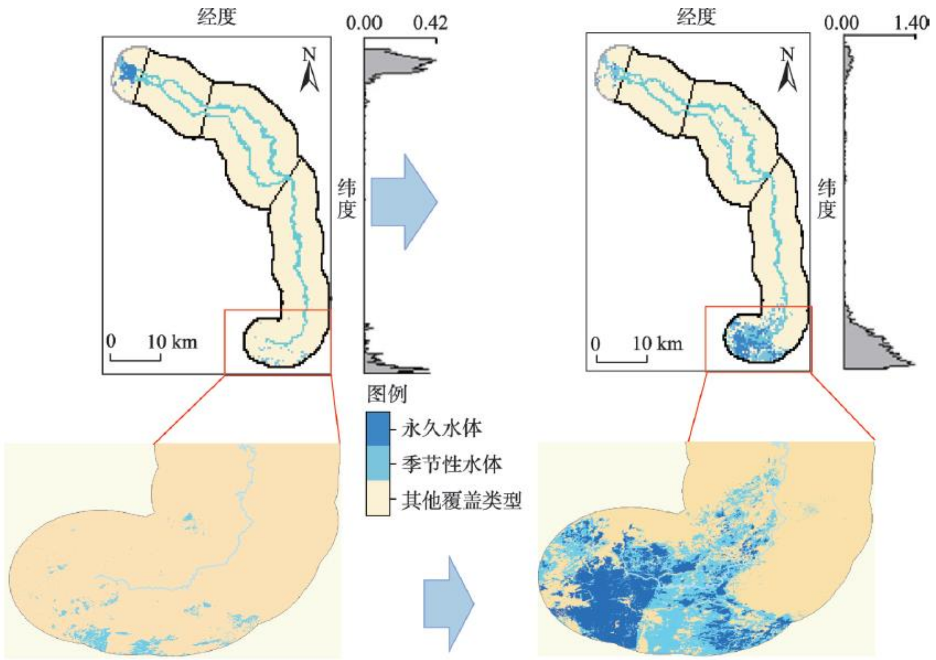


Spatial distribution of water bodies in the lower reaches of the Tarim River from 2000 to 2019

Zou，S etc，Arid Land Geography，2021，44（3）：681-690

- The surface water in the lower reaches of the Tarim River shows obvious spatial uneven distribution and different states with time (left figure).
- Overall, the water body is mainly distributed in the lower part of the study area.
- The proportion of seasonal water bodies in the lower reaches of the Tarim River was relatively large, with an average proportion of 83.60% in 20 years, the largest proportion was 99.87% (2000), and the smallest proportion was 57.31% (2017).
- The year with the largest proportion of permanent water in the total water surface area occurred in 2017 (42.69%), followed by 2019 (39.67%) and 2018 (37.02%).

2.4 Water resources – the amount of ecological water transported has a decisive influence on the area of Lake Taitma

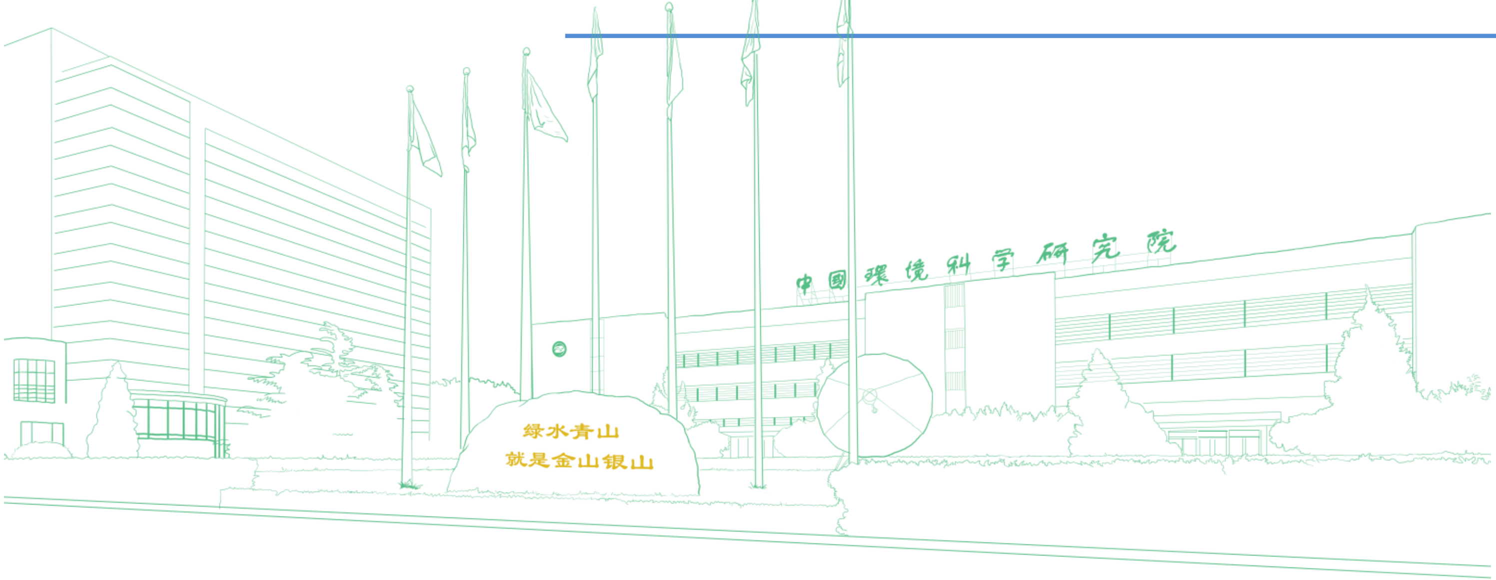


Spatial distribution of surface water area in the beginning year of ecological water transport in the lower reaches of the Tarim River in 2000 (left) and 2019 (right).

Zou , S etc，Arid Land Geography，2021，44（3）：681-690

- The increase in surface water area caused by ecological water transport is mainly reflected in the area change of Lake Taitma.
- In 2000, there was only a small amount of surface seasonal water in the Lake Taitma area, covering an area of about 38.19 km^2. In 2019, both the surface permanent water body and the seasonal water body in the Lake Taitma Lake area showed a significant increase, with an area of about 267.27 km^2 and 188.00 km^2 respectively, and the total water area was about 455.27 km^2, an increase of 417.08 km^2 (about 10.92 times) compared with 2000.

3 Freshwater ecosystem quality assessment in Taitema Lake



3.1 Sampling points

The sample points are set by：

《Technical Regulations for the Design of Water Quality Sampling Schemes(HJ 495-2009)》；

《Lake ecological survey, observation and analysis》；

Number of sampling points：

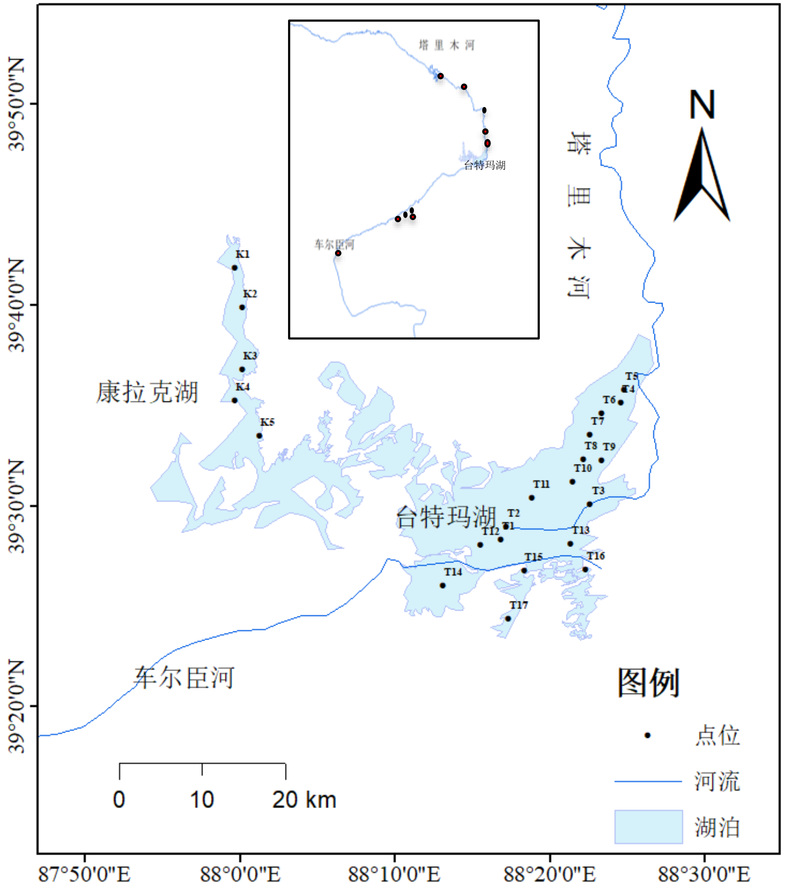
5 monitoring points (Nos. 1-5#) on the Tarim River,

28 monitoring sites (Nos. 6-33#) on Lake Taitma,

5 monitoring sites (Nos. 34-38#) on Lake Conlac,

5 monitoring sites (Nos. 39-43#) on the Chechen River,

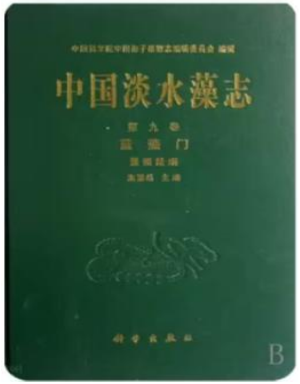
A total of 43 monitoring sections (points)

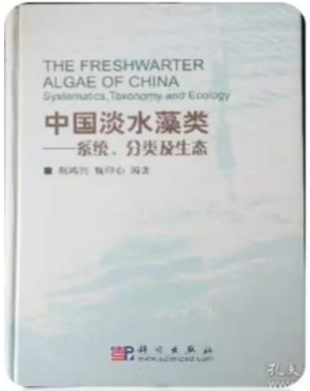


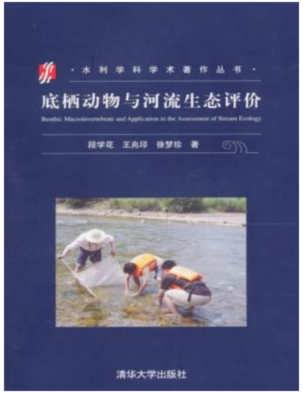
3.2 Technical specifications

- **Refer to the technical guidelines for monitoring and evaluating the quality of the water ecological environment in lakes and reservoirs (draft for comments) and other relevant technical specifications**

《Technical Specification for Environmental Quality Assessment of Surface Water (Draft for Comments) 》 2022;
《Technical Code for Monitoring Environmental Quality of Surface Water》(HJ91.2—2022）;
《Environmental Quality Standard for Surface Water 》(GB 3838-2002);
《Technical Requirements for Aquatic Ecological Monitoring Freshwater Zooplankton (Trial)》 2022;
《Technical Requirements for Water Ecological Monitoring Freshwater Phytoplankton (Trial)》 2022;
《Technical Requirements for Water Ecological Monitoring Freshwater Algae (Trial)》 2022;







3.3 Sampling time and detection indicators

Indicators

Water quality: 24 basic items of surface water environmental quality standards, 48 items such as nitrate, sulfate, chloride, mineralization, salinity, other heavy metals (12 items), DOC, DOM, etc.

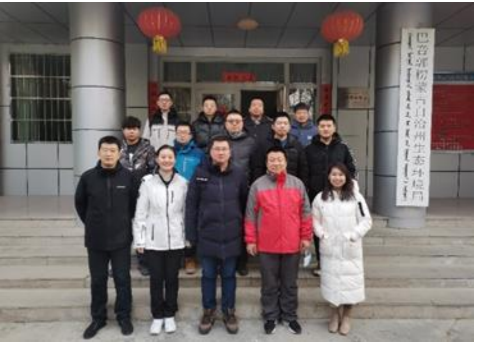
Freshwatre ecoystem: zooplankton, phytoplankton, benthic animals, aquatic plants, fish.

Sampling time

Winter：2022.1.7--1.11；

Spring：2022.3.7--3.10；

Summer：2022.6.8-- 6.11；



3.4 Assessment methodology-**Comprehensive evaluation of freshwater ecosystem**

- **Water environment quality assessment**: Single-factor evaluation and eutrophication evaluation were used.
- **Evaluation of freshwater organisms:** The Shannon-Wiener diversity index.
- **Comprehensive evaluation of frewshwater ecosystem quality:** Refer to the "Technical Guidelines for Monitoring and Evaluation of Water Ecological Environment Quality in Lake and Reservoir (Draft for Comments)" The comprehensive index method is used to carry out the comprehensive assessment of water ecological environment quality, and the comprehensive evaluation index $WEQI_{lake}$ of water ecological environment quality of lakes and reservoirs is constructed by weighted summation of water chemistry indicators (weight 0.5) and aquatic biological indicators (weight 0.5), and the quality status of each assessment unit and the overall water environment is expressed by this index.

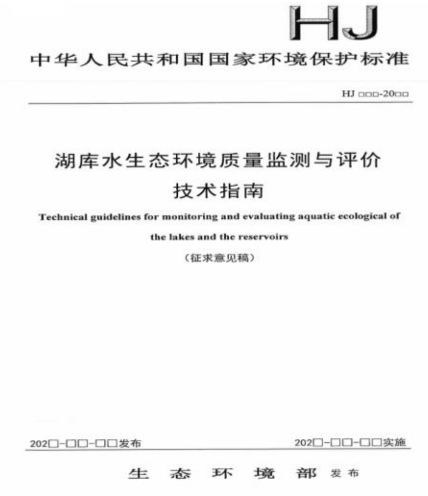
3.4 Assessment methodology-**Comprehensive evaluation of freshwater ecosystem**

Comprehensive evaluation index

$$WEQI_{\text{lake}} = \sum_{i=1}^{n} x_i w_i$$

X_i is the score for evaluation index, w_i is the weight of the evaluation inces

Indices	Score range	Weight for lakes
Water chemistry	1-5	0.5
Freshwater organisms	1-5	0.5


HJ

中华人民共和国国家环境保护标准

HJ □□□-20□□

湖库水生态环境质量监测与评价

技术指南

Technical guidelines for monitoring and evaluating aquatic ecological of the lakes and the reservoirs

（征求意见稿）

202□-□□-□□发布　202□-□□-□□实施

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According to the score of the comprehensive evaluation index ($WEQI_{lake}$) of the water ecological environment quality of the lake reservoir, the water ecological environment quality status level is divided into five levels, which are excellent, good, average, poor, and very poor.

The quality of the aquatic ecological environment	excellent	good	medium	poor	bad
The comprehensive evaluation index （$WEQI_{lake}$）	WEQI＞4	4≥WEQI＞3	3≥WEQI＞2	2≥WEQI＞1	WEQI≤1

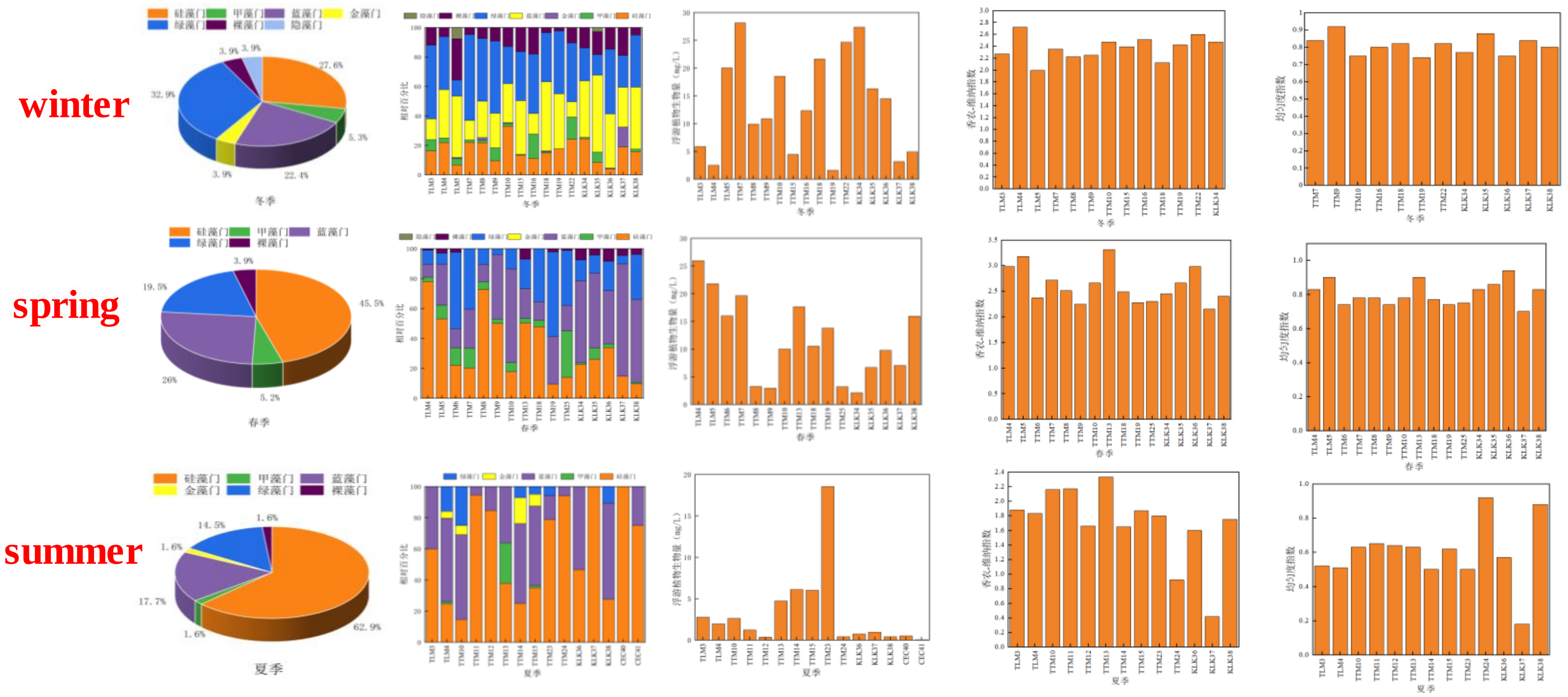
3.4 Assessment methodology-Comprehensive evaluation of freshwater ecosystem

Water chemistry classes	I-II	III	IV	V	Bad V
Water chemistry	Best	Good	Polluted	Moderately polluted	Sevecely polluted
Scores	5	4	3	2	1

Biological index	Best	Good	Polluted	Moderately polluted	Sevecely polluted
Shannon-Wiener	H＞3	2＜H≤3	1＜H≤2	0＜H≤1	H=0
Scores	5	4	3	2	1

3.5 Phytoplankton communities in different seasons

Species composition | Density | Biomass | Shannon-Wiener index | Uniformity Index



There were **164 species of phytoplankton in 36 families in 7 phyla**, mainly **Bacillariophyta, Cyanophyta ,and Chlorophyta**, the proportion of Bacillariophyta species in spring and summer reached 50% to 62.9%, and the species composition, density, biomass and diversity index changed in different seasons.

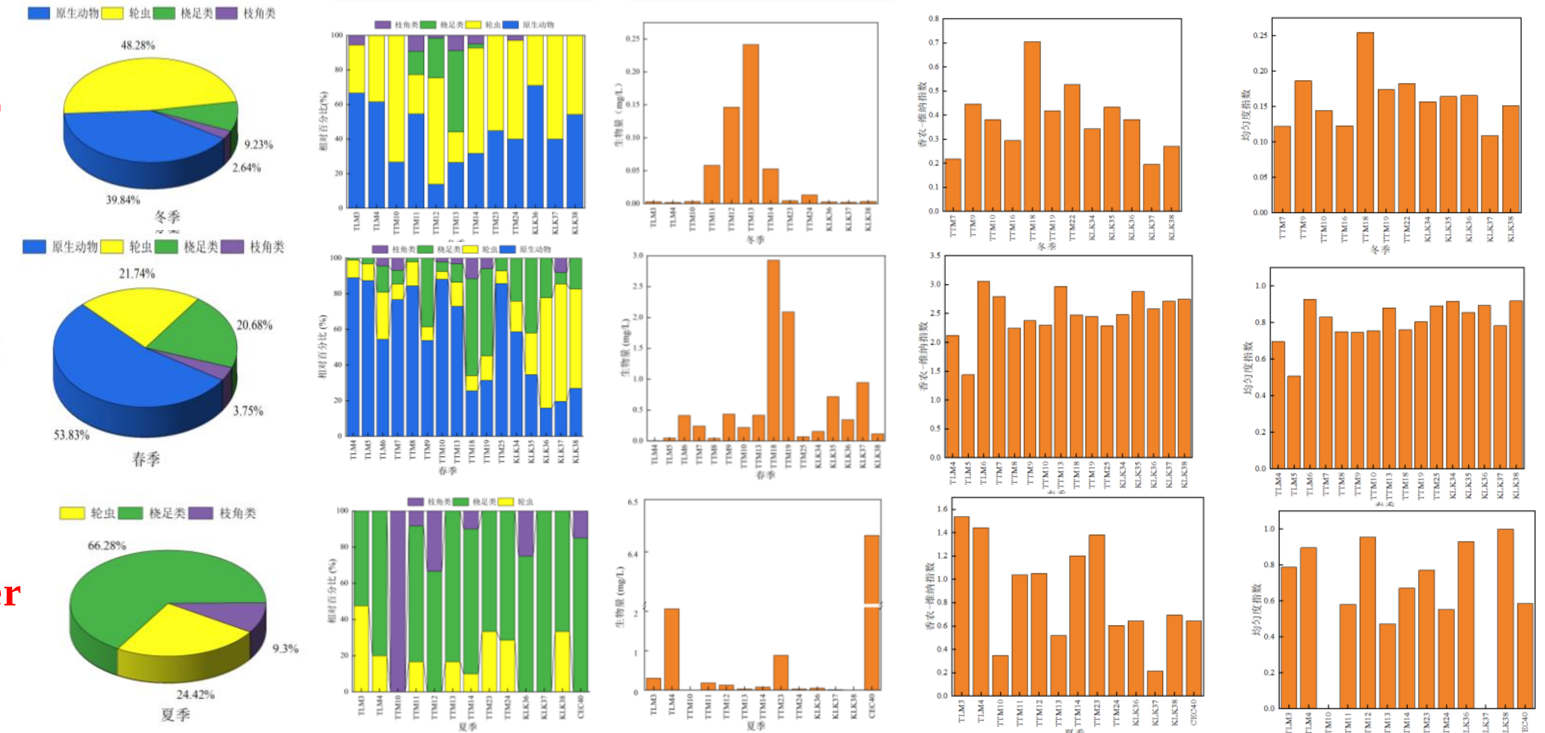
3.6 Zooplankton communities in different seasons

Species composition | **Density** | **Biomass** | **Shannon-Wiener** | **Uniformity Index**

winter

spring

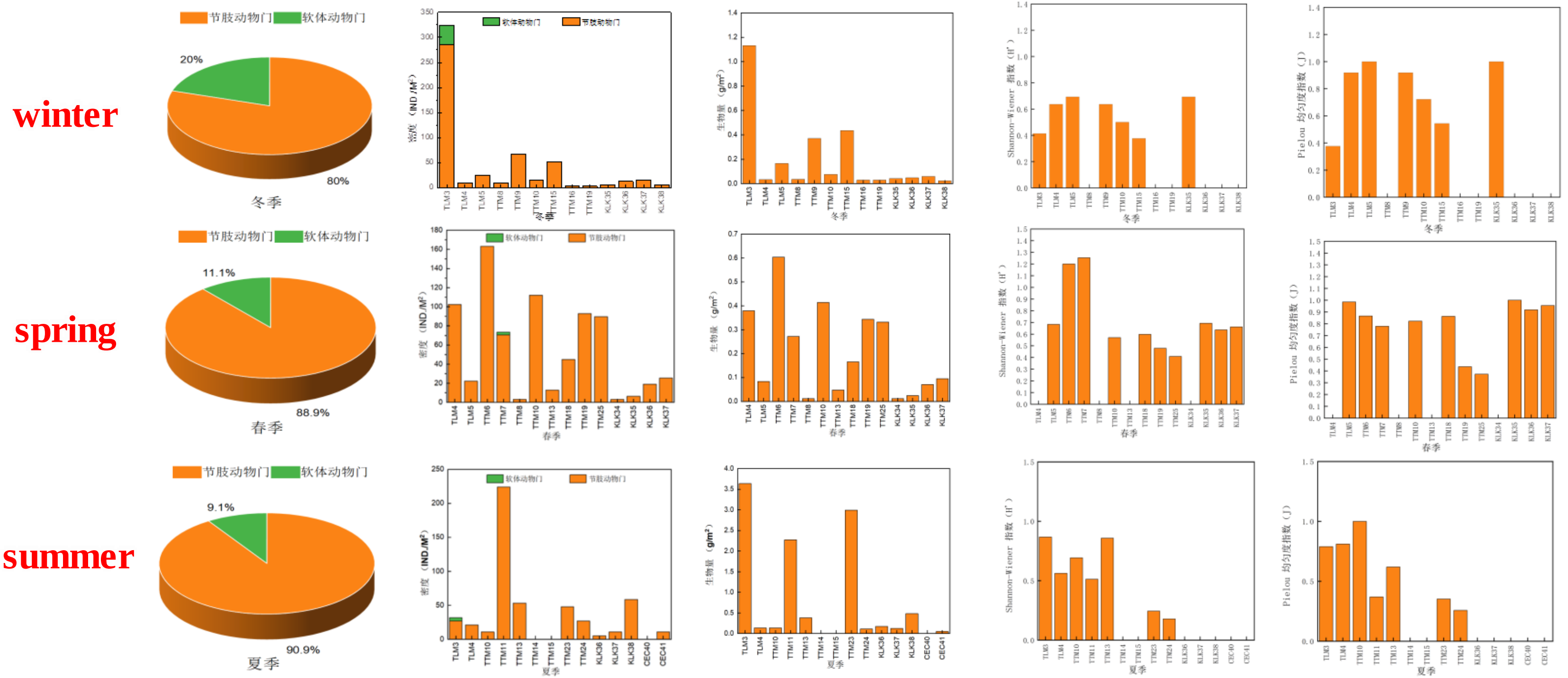
summer



There were 65 species of zooplankton in 4 phyla, 27 families, mainly rotifers and protozoa in winter and spring, summer protozoan taxa are difficult to detect, and the number of rotifers decreased significantly, which may be related to the increase in copepods and cladopods on protozoa and rotifer feeding.

3.7 Macrobenthic invertebrate communities in different seasons

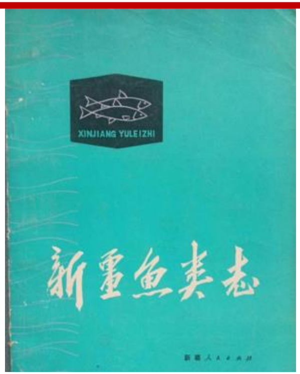
Species composition | **Density** | **Biomass** | **Shannon-Wiener index** | **Uniformity Index**

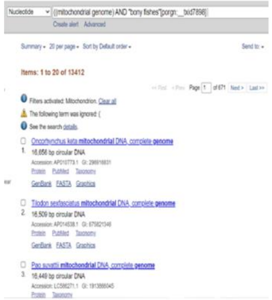


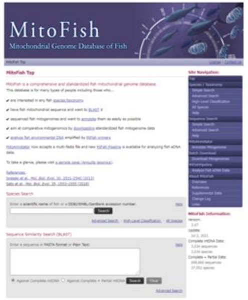
There are 17 species of macrobenthic invertebrates in 2 phyla, 13 families, and the species and number of macrobenthic invertebrate species obtained in the survey of 3 seasons are relatively small, and the Tarim River and Taitma Lake are relatively large.

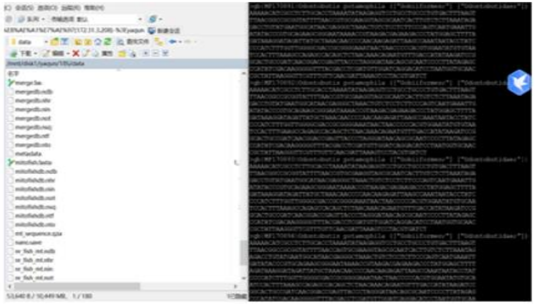
3.8 Fish communities

- **The list of fish DNA barcodes in Xinjiang was systematically summarized, and two public databases and self-owned data were used to build their own datasets**

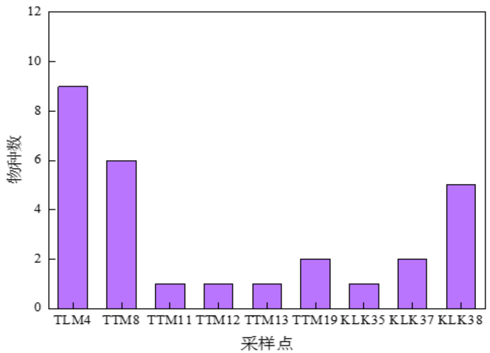




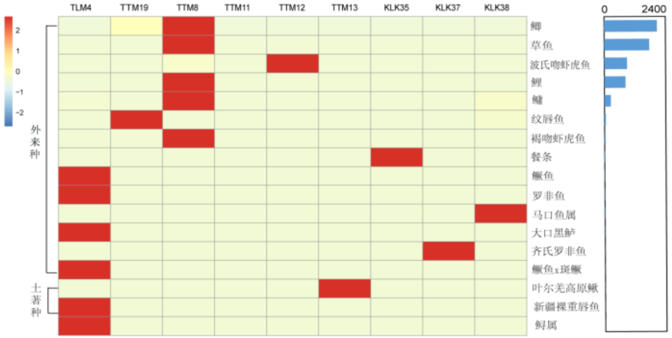




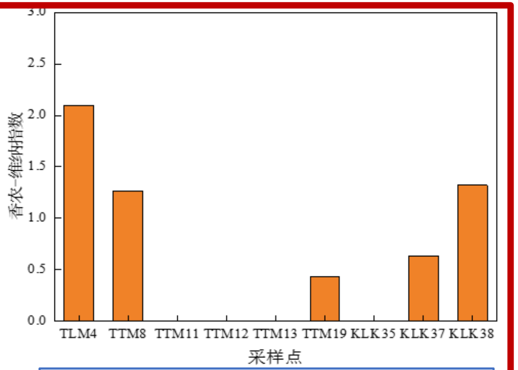
- **Results of environmental DNA monitoring of fish in Lake Taitma in winter: species number, relative abundance and diversity index**



Changes in fish species numbers at different sampling points

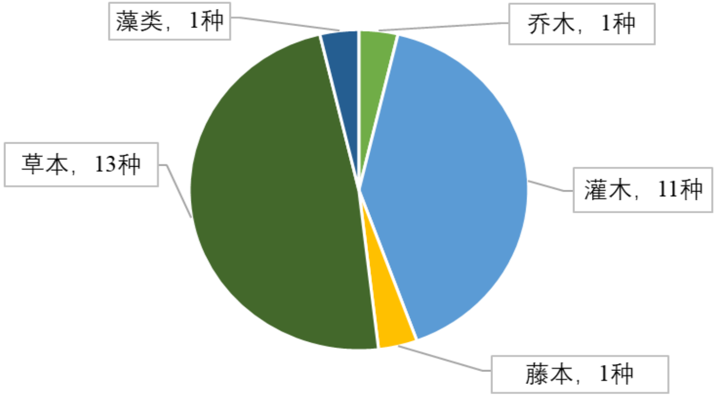


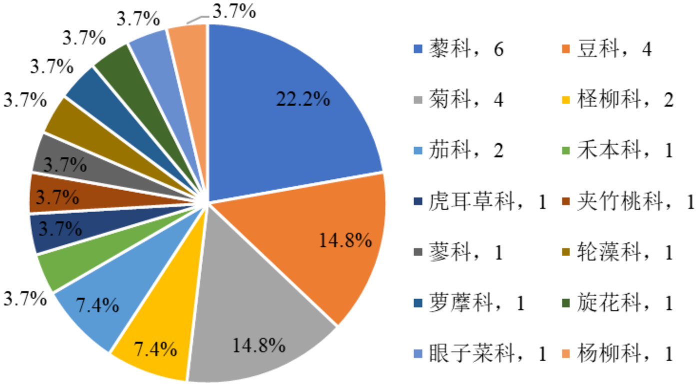
A total of 17 species of fish, including *Triplophysa Yarkandensis* and *Gymnodiptychus dybowskii*, were detected



Changes in the Shannon-Wiener Index at different sampling points

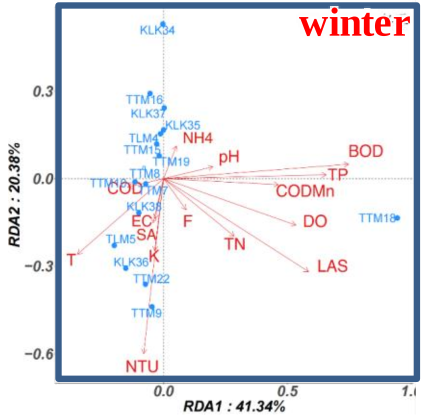
3.9 Riparian and submerged plants

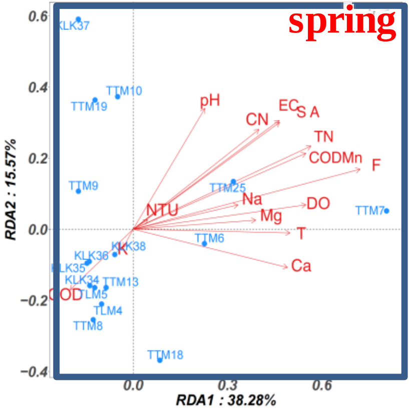


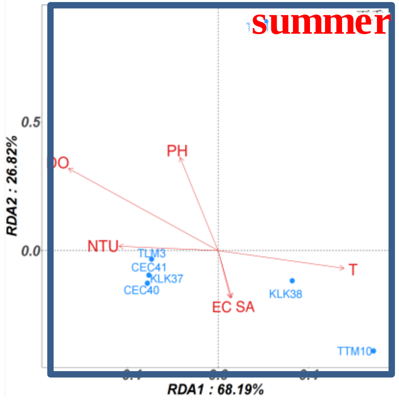


- Recorded altogether 27 species, belonging to 14 families and 25 genera, 1 species of arbor plants, 11 species of shrub plants, 1 species of vines, 13 species of herbaceous plants；
- There were few submerged plants, and only two species, *Chara* and *Stuckenia pectinata*, with frequency of 22.2% and 50.0%, respectively；
- There was only one species of arbor species (*Populus euphratica*), with an average coverage of 55.0% and a frequency of 27.8%；
- **Tamarix chinensis** was the dominant species, with an average cover of 3.0% and a frequency of 33.3%, while other shrub plants appeared only once, including *Tamarix elongata*, *Caragana halodendron*, *Alhagi camelorum*, *Apocynum pictum*, *Inula salsoloides*, and *Halocnemum* Typical sandy plants such as *strobilaceum* and *Haloxylon ammodendron*；
- In the herbaceous plant community, the *Phragmites australis* was the dominant species, with an average cover of 56.3%, and its occurrence frequency was as high as 94.4%

3.10 Correlation analysis between aquatic organisms and environmental factors: community and water quality

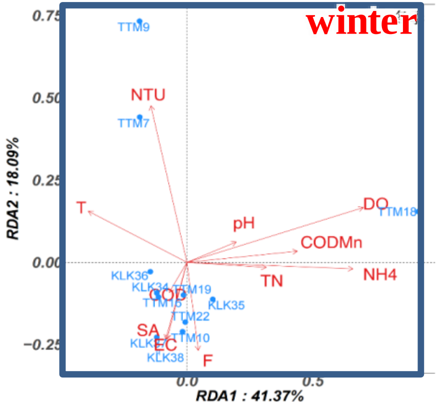


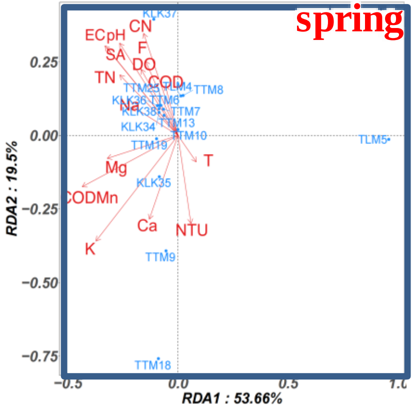


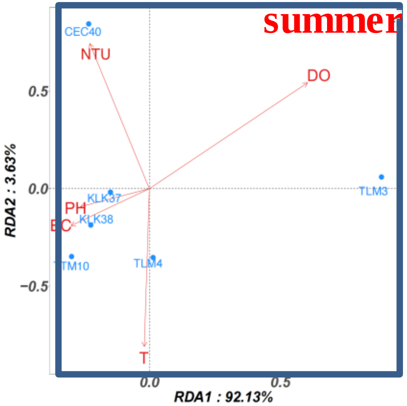


phytoplankton

- **BOD_5、F^- and DO** are the primary key environmental factors affecting phytoplankton communities in winter, spring, and summer, respectively



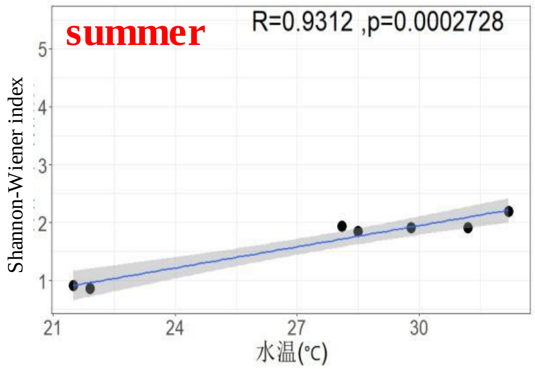


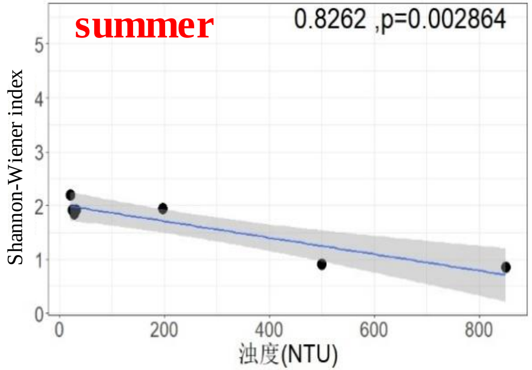


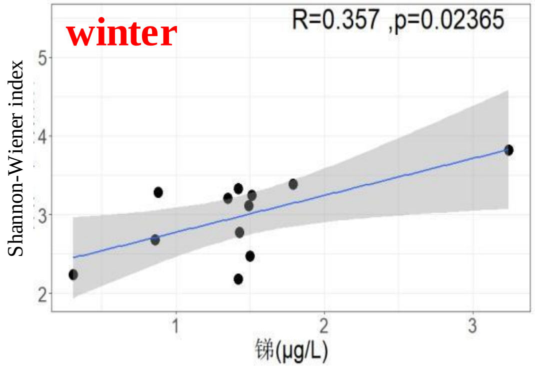
zooplankton

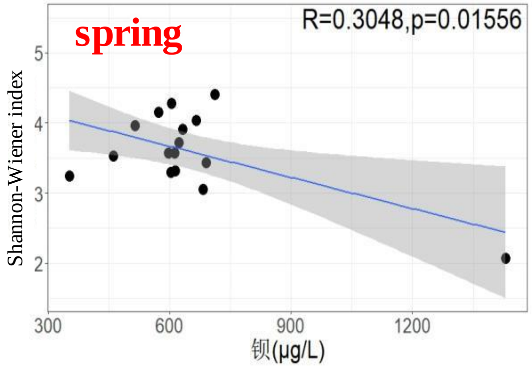
- **DO、 K and DO** are the primary key environmental factors affecting zooplankton communities in winter, spring and summer, respectively

3.11 Correlation analysis between aquatic organisms and environmental factors: diversity and water quality









phytoplankton

- The environmental factors that significantly correlate with changes in phytoplankton α diversity in summer are **water temperature and turbidity**

zooplankton

- Environmental factors significantly associated with changes in zooplankton α diversity in winter and spring were **antimony and barium**, respectively

3.12 Water quality assessment results of Lake Taitma

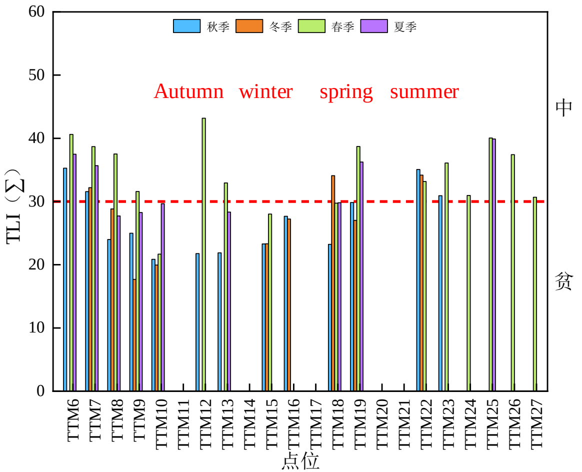
Results of single-factor evaluation of Lake Taitma basin

site	autumn	winter	spring	summer	year-round average
TLM1	I	——	——	——	II
TLM2	II	——	——	——	II
TLM3	II	IV	II	——	II
TLM4	I	II	劣V	劣V	III
TLM5	I	I	III	IV	II
TTM6	劣V	——	劣V	劣V	劣V
TTM7	劣V	劣V	劣V	劣V	劣V
TTM8	II	IV	劣V	劣V	IV
TTM9	I	II	V	III	III
TTM10	I	V	II	劣V	IV
TTM12	V	——	劣V	——	IV
TTM13	I	——	V	劣V	IV
TTM15	I	IV	III	——	II
TTM16	III	IV	——	——	IV
TTM18	II	劣V	IV	IV	III
TTM19	IV	劣V	劣V	劣V	IV
TTM22	劣V	劣V	劣V	——	IV
TTM23	IV	——	劣V	——	IV
TTM24	——	——	劣V	——	劣V
TTM25	——	——	劣V	劣V	劣V
TTM26	——	——	劣V	——	劣V
TTM27	——	——	劣V	——	劣V
KLK34	——	劣V	——	III	IV
KLK35	——	劣V	——	劣V	劣V
KLK36	——	劣V	——	劣V	劣V
KLK37	——	劣V	——	IV	IV
KLK38	IV	劣V	劣V	劣V	劣V
CEC40	——	——	——	II	II
CEC41	I	——	II	II	II
CEC42	I	——	——	——	II
CEC43	I	——	III	——	II

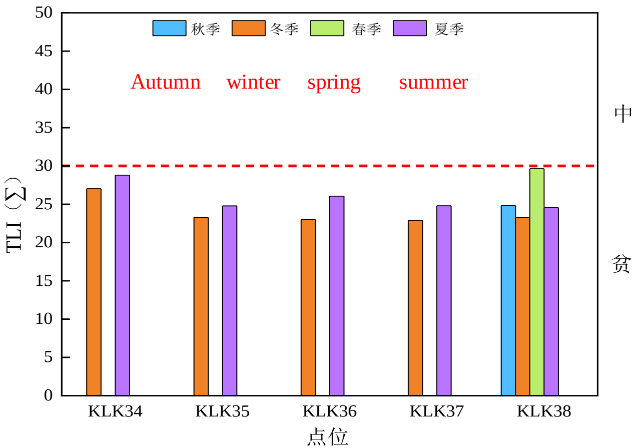
- During the investigation period, 80% of the water quality of the Tarim River met the surface water environmental quality Class II standard, of which the Tarim River No. 4 point met the surface water environmental quality class III. standard and the indicators affecting the water quality category were mainly chemical oxygen demand and total phosphorus.
- The water quality of the Chechen River has reached Class II standard stably, and the overall water quality index is stable;
- The water quality of Taitma Lake is inferior to the surface water environmental quality Class V standard, and the indicators affecting the water quality category of Taitma Lake are mainly fluoride, chemical oxygen demand and total phosphorus.
- The water quality of Conlac Lake meets the surface water environmental quality Class V standard and is moderately polluted, and the indicators affecting the water quality category of Conlac Lake Basin are mainly fluoride, chemical oxygen demand and permanganate index.

3.13 Results of nutrient status evaluation in the Taitma Lake basin

Evaluation of Water Eutrophication state



Lake Taitma Composite Trophic Status Index



Lake Tetma Composite Trophic Status Index

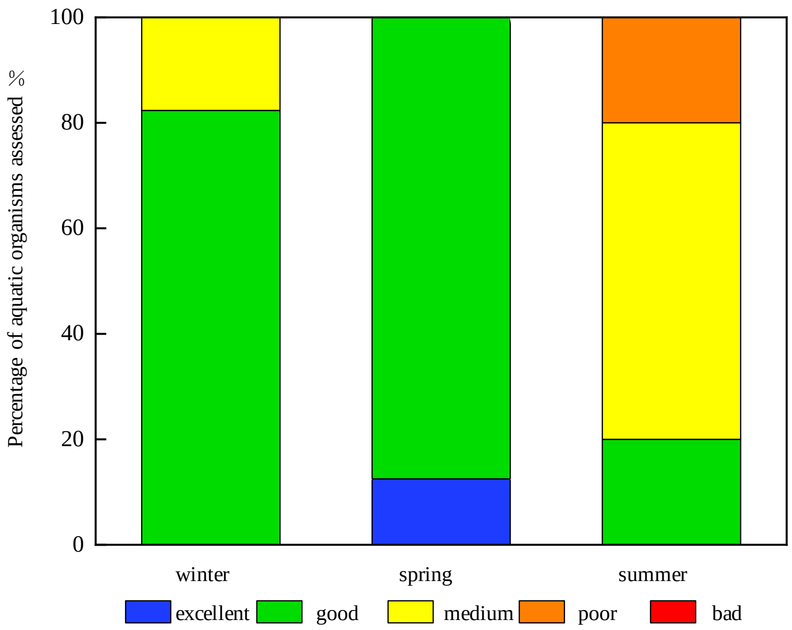
The average annual TLI index of Lake Taitma is 30.28, which is in a moderate trophic state.

- The average value of the winter TLI index was 27.17, which was in a nutrient-poor state;
- The average value of the spring TLI index was 34.44, which was in a moderate trophic state.
- The average value of the summer TLI index is 32.57, which is in a moderate trophic state.

The average annual TLI index of Conlac Lake is 26.04, which is in a nutrient-poor state and is in a nutrient-poor state in all seasons.

3.14 Biological evaluation results

Evaluation of organisms



Evaluation results of aquatic organisms in different seasons in the Taitma Lake basin

- phytoplankton Shannon-Wiener diversity index assessment :

Winter: the proportion of "good" grade in all sampling points was 82.35%, and "medium" grade was 17.65%.

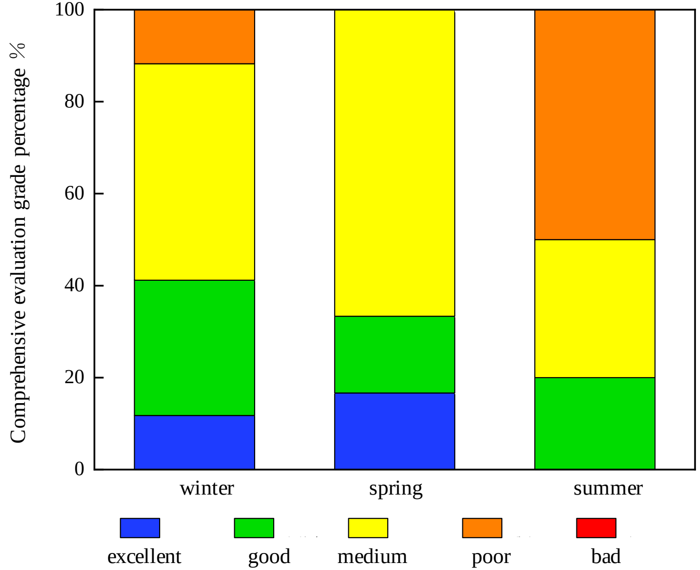
Spring: The proportion of "excellent" grades 12.5% and "good" 87.5% ,

Summer: 20% for "good" grades, 60% for " medium " grades, and 20% for "poor" grades;

- Therefore, from the seasonal changes in the aquatic ecological health status of the Taitma Lake basin, spring is better than winter, and winter is better than summer.

3.15 Comprehensive evaluation of water ecological environment quality

Comprehensive evaluation of water ecological environment quality



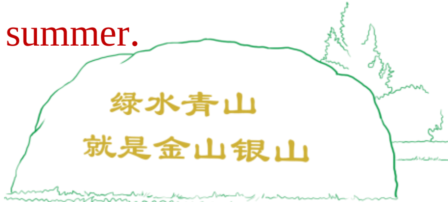
Comprehensive evaluation results of different seasons in the Taitma Lake basin

Winter: The proportion of "excellent" "good" "medium" "poor" grades in all sampling points was 11.76%, 29.41%, 47.06% and 11.76%

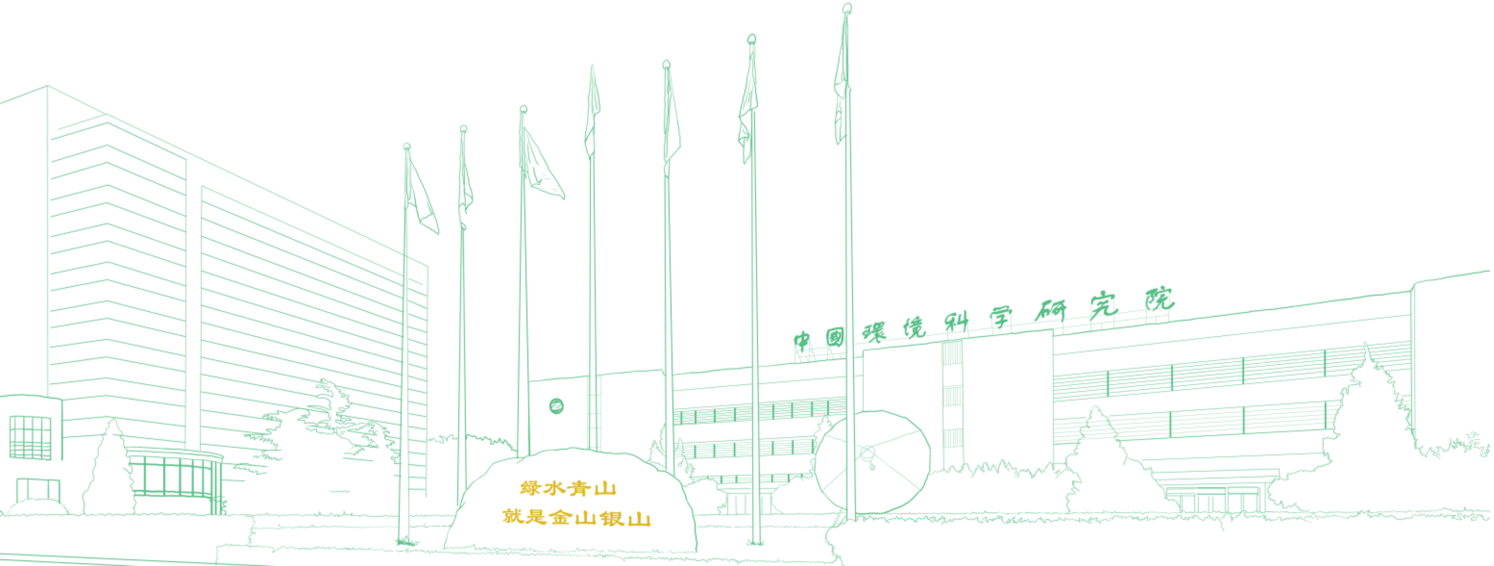
Spring: The proportion of "excellent" "good" "medium" grades in all sampling points was 16.67%, 16.67%, 66.67%;

Summer: The proportion of sampling points for "good" “medium" "poor" grades was 20%, 30%, 50%;

From the seasonal changes of the comprehensive evaluation of aquatic ecological environment quality in the Taitma Lake Basin, spring is better than winter, and winter is better than summer.



4 Conclusions



Conclusions

（1） Freshwater communities showed obvious spatial and temporal distribution patterns.

- a total of 164 species of 7 phylum and 36 families for phytoplankton,
- 65 species of 4 phylum and 27 families of phylum in 4 phyla,
- 17 species of macrobenthic invertebrates in 4 phylum and 13 families,
- 17 species of fish,
- 27 species in 25 genera and 14 families and aquatic plants were obtained.

（2） The comprehensive evaluation of the quality of freshwater ecosystem in the Taitema Lake Basin was best in spring and worst in summer.

（3） Seasonal changes and ecological water replenishment have obvious effects on the freshwater ecosystem of Lake Taitema.

The annual evaporation of Taitma Lake is higher than the intake, and the spring and summer of Taitma Lake Basin are in the process of continuous evaporation, and the high evaporation in summer leads to obvious degradation of the overall water ecological status of Taitma Lake Basin, which further indicates that water diversion and replenishment have a positive effect on the maintenance of freshwater ecological health in the Taitma Lake Basin.

（4） The water body of Lake Taitma is in a moderate nutrient status in spring and summer, and supervision and protection should be strengthened to prevent eutrophication;

Thank you for your watching!