Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2021.26839

219 (2021) 206–216
April

The ecological structure distribution characteristics of aquatic plant community in Scenic Island

Wensheng Huang

Aviation and Tourism College, Guilin University of Aerospace Technology, Guilin 541004, China, email: Hans1888@163.com

Received 15 August 2020; Accepted 23 November 2020

ABSTRACT

In this paper, the island of tourist attraction is selected as the research area, and the aquatic plants of 30 sample spots in spring, summer, and autumn are investigated, and the species distribution and community characteristics of aquatic plants are analyzed, so as to put forward suggestions for the restoration and protection of aquatic plants in scenic spots. It is found that there are 24 species of aquatic plants distributed in 14 families in the islands of tourist attractions in 2019, among which *Potamogeton crispus*, lotus, and *Ceratophyllum demersum* are the dominant species. There are differences in the growth of aquatic plants in different seasons. *P. crispus* is widely distributed in spring, and lotus and *C. demersum* are dominant species in summer and autumn. The dominant communities in different seasons and locations are different. *P. crispus* community is the dominant community in spring, while Lotus community and *C. demersum* community are dominant communities in summer and autumn. The dominant degree of community distribution in different scenic spots is also different, mainly due to the quality of water.

Keywords: Tourist attractions; Aquatic plants; Community ecological structure; Structural distribution characteristics

1. Introduction

The comprehensive protection and management of water environment cannot be separated from the research, protection, and utilization of aquatic plants [1–3]. As an important part of wetland ecosystem, aquatic plants play an extremely important supporting role in the structure and function of the ecosystem [4,5]. From the perspective of food chain, aquatic plants are the primary producers of aquatic ecosystem [6,7], which provide oxygen in water body and provide food and habitat for other organisms. Aquatic organisms such as fish can also regulate the population structure of plants through interaction with submerged plants in water [8]. Therefore, aquatic plants in material cycle, energy flow, and maintain the whole life. The balance of the state system plays an irreplaceable role [9], especially in the shallow lake ecosystem [10].

As an important part of aquatic biological community, the changes of its population and community diversity are often related to the healthy development of aquatic ecosystem [11]. The functions of aquatic plants are mainly manifested in the following aspects: purifying water quality, maintaining clear water state of water body, solidifying sediment, increasing transparency, reducing and avoiding the outbreak of water bloom, inhibiting excessive propagation of algae, and improving species diversity of water ecosystem [12]. Therefore, the protection and restoration of aquatic plants is of great significance for the maintenance of aquatic ecosystem basin environment and biodiversity [13].

In this paper, a tourist island was selected as the research area. Through the field survey and sampling of Lake Wetland in different seasons, the relevant indicators of aquatic plant community were recorded in detail, and the temporal and spatial distribution law of plant species and quantity in island wetland of tourism scenic area were

obtained. The community structure and biodiversity of the area were analyzed. At the same time, water samples were collected for detection of relevant physical and chemical indicators This paper discusses the influence of environmental factors on the growth and distribution of submerged plants, in order to provide scientific reference for the management of aquatic plants in the island wetland of tourist attractions and the protection and restoration of island diversity in tourist attractions.

2. Materials and methods

2.1. Overview of regional studies

The main vegetation types of the island in a tourist attraction are warm temperate deciduous broad-leaved forest and temperate grassland. The former is distributed in most areas of the basin, while the latter is only distributed in Lingqiu and nearby areas. The scenic area is rich in species of herbs and broadleaved vegetation, including not only natural forest and broadleaf forest, but also wetland vegetation. At the same time, the study area is also an important passage and stop point for migratory birds. Abundant plant resources provide sufficient food and habitat for all kinds of animals, especially migratory birds, so it has important research value.

2.2. Layout of sampling points

According to the geographical location, topography, and water environment status of the island in the scenic spot, combined with the layout of national control points of environmental departments, and considering the layout of water inlet, outlet (upstream and downstream), and industry (tourism and aquaculture), the scenic area with an area of more than 100 Mu was investigated. A total of 30 stations were set up. In order to accurately reflect the water environment and plant distribution in the survey area, the sample points were basically covered all scenic spots in the island [14], each scenic spot is set with one or two sampling points (some scenic spots are set with two sampling points due to their large area). The description of each sampling point is shown in Table 1.

2.3. Sampling method

In this study, in May, August, and October of 2019, the aquatic plants in the scenic spots were sampled in spring, summer, and autumn, and the plant samples and water samples were obtained, respectively. Field investigation tools include aquatic plant collector (water grass clip), water sampler, thermometer, hygrometer, transparency disk, etc.

The species of aquatic plants in each sampling point were identified and their coverage and density were determined. At the sampling point, a plant collector was used to capture 5 times randomly with a reference of 1 m^2 (due to the field operation on the ship, so the hull was taken as the reference). The plant species, density, frequency, and height of each species were recorded, respectively. The plant biomass was determined as wet weight. The collected plants were put into the plastic bag for weighing and recording data, with the unit of G. The collected plant samples were taken back to the laboratory for cleaning and natural air drying, and then the dry weight was measured.

2.4. Data analysis

In this study, through the field investigation of the Island Lake Wetland in the scenic spot, the data of aquatic plant species, biomass, water depth, water transparency, and water temperature were obtained, and then some physical and chemical index data of water quality samples were obtained through experiments. The preliminary experimental data were compiled into tables by Excel software.

3. Spatiotemporal distribution characteristics of aquatic plant communities on islands in tourist attractions

3.1. Species and distribution of aquatic plants

In this study, three different seasons were selected to conduct field investigation on the selected sample sites in May, July, and October, 2019, namely, spring, summer, and autumn. After investigation, 24 species of aquatic plants were found in the island, including six emergent plants, six root floating leaf plants, three floating plants, and nine submerged plants. According to the life form, there are six species of emergent plants, accounting for 25% of the total plants; include *Nelumbo nucifera*, *Nymphaea tetragona*, *Phragmites australis*, *Typha angustifolia*, *Zizania caduciflora*, and *Echinochloa crusgalli*.

There are nine species of submerged plants, accounting for 20.8% of the total plants; include *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Utricularia vulgaris*, *Potamogeton crispus*, *Potamogeton pectinatus*, *Potamogeton malaianus*, *Najas minor*, *Hydrilla verticillata*, and *Vallisneria asiatica*.

There are six species of floating leaf root plants, accounting for 25% of the total number of plants; include *N. nucifera*, *N. tetragona*, *Nymphoides peltata*, *Euryale ferox*, *Hydracharis dubia*, and *Alternanthera philoxeroides*.

There are three species of floating plants, accounting for 12.5% of the total plants *Lemna paucicostata*, *Spirodela polyhiza*, and *Salvinia natans*, as shown in Table 2.

The island vegetation in the scenic spot is mainly aquatic vegetation, reed, *T. angustifolia*, *Hydrilla verticillata*, *P. crispus*, and so on are the economic aquatic plants in the lake. From the time distribution, we can see that there are more plant species in August (summer) than in May (spring) and October (autumn). In terms of plant growth season, most aquatic plants begin to germinate and grow around May. In summer and autumn, they are in the growth peak period. In winter, they begin to wither and die due to low temperature, so there are almost no plants in winter. Therefore, there are a little less plants in spring, which is in line with the law of plant growth. Since the temperature in North China has turned cold in October, the growth rate of plants slows down and the species decreases. In addition to temperature, there are also water level reasons. From the change of water level of the island shown in Fig. 1, it can be seen that the water level in the autumn of 19 y increased significantly, and the survey area had risen to more than 7 m in September. At this time, some plants in the

Table 1
Environmental characteristics of each sampling point

Sampling point	Environmental description
S1 scenic spot 1a	It is close to the village and used to be a breeding area covered with lotus
S2 scenic spot 1b	It was originally a breeding area, with many boats passing by, with lotus flowers around
S3 scenic spot 2	There are few aquatic plants in the culture area
S4 attractions 3	The aquatic plants are relatively simple, and the main one is Potamogeton castor
S5 attractions 4	The water body is clear with submerged plants
S6 scenic spot 5	Around the village, algae Lake area
S7 scenic spot 6	Neighboring village
S8 scenic spot 7	The water is clear
S9 scenic spot 8	The water is clear and transparent
S10 scenic spot 9	The water area is large and the water is clear
S11 scenic spot 10	It is in recovery state and the water is clear
S12 scenic spot 11	The water area is large and the water body is clean
S13 scenic spot 12	The water is turbid
S14 scenic spot 13	There are basically no aquatic plants
S15 scenic spot 14	The water is clear
S17 scenic spot 16	Open water
S18 scenic spot 17	The water body is poor
S18 scenic spot 17a	There are less plants, and the cruise ship has a greater impact
S19 scenic spot 17b	There are less plants, and the cruise ship has a greater impact
S20 attractions 18	Close to the scenic area, the water area is wide, and it is greatly affected by tourism
S21 attractions 19	Open waters, tourism has a great impact
S22 scenic spot 20	Open water, less human impact
S23 scenic spots 21a	There are many plants
S24 scenic spot 21b	There are many plants
S25 scenic spot 21c	There are many plants
S26 scenic spots 21d	There are many plants
S27 attractions 22	The water is clear and the submerged plants are abundant
S28 scenic spots 23	The water quality is poor
S29 attractions 24	There is domestic garbage in the water
S30 attractions 25	The water quality is turbid, and the surrounding areas are residential areas. There are domestic garbage in the water

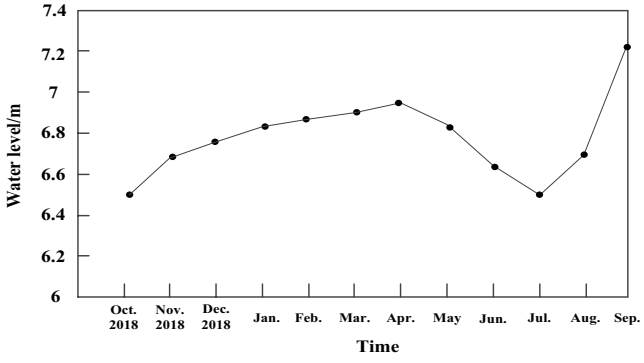

Fig. 1. Water level change from October 2018 to September 2019.

water died due to the increase of water level, such as *P. crispus*. In terms of regional distribution, aquatic plants are more likely to be distributed in areas where the flow velocity is low and is not disturbed by the flow of large lakes.

3.2. Analysis of community type characteristics and distribution

3.2.1. Analysis of aquatic plant community characteristics of islands in different seasons

In spring, there are 16 species of aquatic plants in island wetland of tourist attractions, which belong to 10 families and 13 genera. As shown in Table 3. In summer, there are 16 species of aquatic plants in island wetland of tourist attractions, belonging to 10 families and 13 genera respectively, as shown in Table 4. The largest number of species in the family is *Nymphaeaceae*, accounting for 15% of the total number of species, including *E. ferox*, lotus, and water lily, followed by Gramineae and Shuibiedaceae, both containing two plants.

In autumn, there are 15 species of aquatic plants in the investigated area, belonging to 13 families and 15 genera, as shown in Table 5. *Nymphaeaceae* and *Pelodidaceae* have the largest number of species, accounting for 13% of the total number of species. The other families contain only one plant. It can be seen that the distribution of plant families and genera in the

Table 2
List of aquatic plants in the scenic area

Section	Species	Spring	Summer	Autumn
Gramineae (3)	*Echinochloa crusgalli*		+	
	Phragmites communis	+	+	+
	Zizania caduciflora	+		
Typhaceae (1)	*Typha angustifolia*	+	+	+
Cyperaceae (2)	*Scirpus validus* vahl		+	
	Scirpus triqueter l.		+	
Nymphaeaceae (3)	*Nymphaea tetragona*	+	+	+
	Euryale ferox		+	
	Nelumbo nucifera	+	+	+
Potamogetonaceae (3 kinds)	*Potamogeton crispus*	+		
	Potamogeton pectinatus	+	+	+
	Potamogeton wrightii	+		
Najadaceae (1)	*Najas minor*	+	+	+
Lemnaceae (2)	*Spirodela polyrhiza*		+	+
	Lemna perpusilla		+	
Haloragidaceae (1)	*Myriophyllum spicatum*	+	+	+
Gentianaceae (2)	*Nymphoides peltatum*	+	+	+
	Hydrilla verticillata		+	+
Hydrocharitacea (2)	*Hydrocharis dubia*	+	+	+
	Vallisneria asiatica	+		
Ceratophyllaceae (1)	*Ceratophyllum demersum*	+	+	+
Lentibulariaceae (1)	*Utricularia vulgaris*	+	+	+
Salviniaceae (1)	*Salvinia natans*		+	+
Amaranthaceae (1)	*Alternanthera philoxeroides*			+

Table 3
Species of island plants in spring

Serial number	Species (Latin)	Family name	Generic name
1	*Phragmites communis*	Gramineae	Phragmites
2	*Zizania caduciflora*		Zizania
3	*Typha angustifolia*	Typhaceae	Typha
4	*Nymphaea tetragona*	Nymphaeaceae	Nymphaea
5	*Nelumbo nucifera*		Lotus
6	*Potamogeton crispus* l.	Potamogetonaceae	Potamogeton
7	*Potamogeton pectinatus*		Potamogeton
8	*Potamogeton wrightii*		Potamogeton
9	*Najas minor*	Najadaceae	Najas
10	*Myriophyllum spicatum*	Haloragidaceae	Myriophyllum
11	*Nymphoides peltatum*	Gentianaceae	Nymphoides
12	*Hydrocharis dubia*	Pelodidae	Eupolyphaga
13	*Vallisneria asiatica*		Vallisneria
14	*Ceratophyllum demersum*	Ceratophyllaceae	Ceratophyllum
15	*Utricularia vulgaris*	Lentibulariaceae	Utricularia

survey area is relatively scattered, and the plant composition is more complex, as shown as follows.

3.2.2. Composition of dominant plants

In the species survey, field survey is used to record the basic quantitative characteristics such as plant abundance, height, and coverage, but single basic quantitative characteristics cannot accurately reflect the status of the species in the community. The importance value [15] is a comprehensive index that can reflect the status of plants in the community, which can more scientifically and effectively reflect the dominance of a plant in the community. The higher the importance value of a plant, the greater the dominance of the species in its community. The calculation method of important value is as follows:

$$I = \frac{H + G + P}{3} \quad (1)$$

where H is the relative height, G is the relative coverage, and P is the relative frequency.

- Changes of plant importance in different seasons

In spring, the important values of plants in island lakes and wetlands in scenic spots are shown in Table 6. Based on the number of species in each family, the dominant family is *Potamogeton* family, including three species. Based on the important value, the dominant family is still *Potamogeton* family, and the cumulative important value is 0.298 [16]. It can be seen that the overall dominant family of the islands in the tourist attractions in spring is *Potamogeton* family. In addition, the important value of the family was 0.070, 0.063, 0.039, and 0.030, respectively. The importance of other branches is relatively small, and rarely appears in the actual investigation. In terms of the important value of a single species, *P. crispus* has the largest value, which is 0.173. *P. crispus* grows vigorously in spring in tourist attractions, and most scenic spots have growth.

The important values of wetland plants in summer are shown in Table 7. Based on the number of species in each family, the dominant family is *Nymphaeaceae*, including three plants, namely lotus, water lily, and *E. ferox*, accounting for 8% of the total family number, followed by Gramineae, which also includes three plants, Cyperaceae and Pelaginaceae, both containing two plants. Based on the importance value, the dominant family is nymphaeace, the important value of which is 0.229, and Gramineae, *Ceratophyllum*, *Potamogeton*, etc., with the important value above 0.1 [17]; in terms of the important value of single species, the most important value of aquatic plants is lotus in summer, the important value is 0.183, and summer is the important growing season of lotus. The results showed that the growth rate of Jinlian was significantly higher than that of other scenic spots.

The important values of aquatic plants in autumn are shown in Table 8. According to the number of species in each family, the dominant families are *Pelodidaceae* and *Nymphaeaceae*, both of which contain two kinds of plants, accounting for the total number of families, while the other families contain only one plant. According to the important value of families, the dominant families were *Nymphaeaceae* (0.268), followed by ceratophyceae (0.227), and the other families were Gramineae, Potamogeraceae, Typhaceae, and Pelodiaceae, with an important value above 0.1. The dominant species was Lotus (0.252), followed by *C. demersum*

Table 4
List of island plants in summer

Serial number	Species (Latin)	Family name	Generic name
1	*Echinochloa crusgalli*	Gramineae	Echinochloa
2	*Phragmites communis*		Phragmites
3	*Typha angustifolia*	Typhaceae	Typha
4	*Scirpus validus* vahl	Cyperaceae	Scirpus
5	*Scirpus triqueter* l		Scirpus
6	*Nymphaea tetragona*	Nymphaeaceae	Nymphaea
7	*Euryale ferox*		Euryale
8	*Nelumbo nucifera*		Lotus
9	*Potamogeton pectinatus*	Potamogetonaceae	Potamogeton
10	*Najas minor*	Najadaceae	Najas
11	*Spirodela polyrhiza*	Lemnaceae	Spirodela
12	*Lemna perpusilla*		Lemna
13	*Myriophyllum spicatum*	Haloragidaceae	Myriophyllum
14	*Nymphoides peltatum*	Gentianaceae	Nymphoides
15	*Hydrilla verticillata*	Hydrocharitacea	Black algae
16	*Hydrocharis dubia*		Eupolyphaga
17	*Ceratophyllum demersum*	Ceratophyllaceae	Ceratophyllum
18	*Utricularia vulgaris*	Lentibulariaceae	Utricularia
19	*Salvinia natans*	Salviniaceae	Sophora

Table 5
Species of island plants in autumn

Serial number	Species (Latin)	Family name	Generic name
1	*Phragmites communis*	Gramineae	Phragmites
2	*Typha angustifolia*	Typhaceae	Typha
3	*Nymphaea tetragona*	Nymphaeaceae	Nymphaea
4	*Nelumbo nucifera*		Lotus
5	*Potamogeton pectinatus*	Potamogetonaceae	Potamogeton
6	*Najas minor*	Najadaceae	Najas
7	*Spirodela polyrhiza*	Lemnaceae	Spirodela
8	*Myriophyllum spicatum*	Haloragidaceae	Myriophyllum
9	*Nymphoides peltatum*	Gentianaceae	Nymphoides
10	*Hydrilla verticillata*	Hydrocharitacea	Black algae
11	*Hydrocharis dubia*		Eupolyphaga
12	*Ceratophyllum demersum*	Ceratophyllaceae	Ceratophyllum
13	*Utricularia vulgaris*	Lentibulariaceae	Utricularia
14	*Salvinia natans*	Salviniaceae	Sophora
15	*Alternanthera philoxeroides*	Amaranthaceae	Alternanthera L

Table 6
Important values of aquatic plants in island lakes and wetlands of tourist attractions in spring

Family name	Species name	Important value	Family importance
Potamogetonaceae	*Potamogeton crispus*	0.173	0.298
	Potamogeton pectinatus	0.125	
Hydrocharitacea	*Hydrocharis dubia*	0.03	0.03
Ceratophyllaceae	*Ceratophyllum demersum*	0.039	0.039
	Phragmites communis	0.006	
Gramineae	*Typha angustifolia*	0.035	0.063
	Zizania caduciflora	0.022	
Gentianaceae	*Nymphoides peltatum*	0.008	0.008
Haloragidaceae	*Myriophyllum spicatum*	0.07	0.07

(0.227). It can be seen that lotus and *Ceratophyllum* are still the dominant plants in autumn.

The community types of each sample plot were divided according to the importance value of each species in the community. The results are shown in Table 9. The dynamic changes of plant community types were obvious in different seasons. It can be seen from the table that *P. crispus* community is dominant in spring, and the dynamic changes in summer and autumn are more obvious than that in spring. Among them, S14, S20, and S22 were algae lakes, and no aquatic plants were found in the survey. No plants were found in spring and summer, but gradually recovered in autumn, and began to appear water turtle + goldfish algae community. The dominant communities of S1 and S2 are *P. crispus* community in spring, lotus + *C. demersum* community in summer, and lotus + *C. demersum* community in autumn [18]. It can be seen that lotus is the dominant species in spring, followed by *C. demersum* in the scenic spot. The community of *P. crispus* + lotus in spring and lotus in summer and autumn was dominant in S3. The dominant community in S4 was Potamogeton castor in summer and autumn. In spring, the dominant community of sample S5 was *M. spicatum* + *Pteridium aquilinum* community. In summer and autumn, it changed into Potamogeton castanoides community. The results showed that there were no too many plants in spring in s23–26, and the seasonal changes in summer and autumn were basically the same. In summer, lotus + water turtle + Potamogeton castor was the dominant community. Lotus was still the dominant species in autumn, and *Azolla japonica* and Azolla became the other dominant species.

In addition to the mixed community of *P. crispus* and *M. spicatum* in spring, the dominant community in summer and autumn was *M. spicatum*. It can be seen that the water quality of the scenic spot is good and suitable for the growth of *Myriophytum spicatum*. The results showed that there were three seasons of S8 *Potamogeton ricini*. Except spring and *P. crispus* formed the dominant community, the dominant community in summer and autumn was the mixed community of *P. ricini* and lotus. The results showed that there were significant seasonal dynamic changes in the scenic spots of S6, S7, S10, S11, S12, S15, S21, S29, and S30,

Table 7
Important values of aquatic plants in island lakes and wetlands of tourist attractions in summer

Family name	Species name	Important value	Family importance
Gramineae	*Phragmites communis*	0.105	0.222
	Zizania caduciflora	0.031	
	Typha	0.086	
Nymphaeaceae	*Euryale ferox*	0.008	0.229
	Nelumbo nucifera	0.183	
	Nymphaea tetragona	0.038	
Hydrocharitacea	*Hydrocharis dubia*	0.064	0.07
	Hydrilla verticillata	0.006	
Ceratophyllaceae	*Hydrilla verticillata*	0.166	0.166
Potamogetonaceae	*Potamogeton pectinatus*	0.1	0.1
Haloragidaceae	*Myriophyllum spicatum*	0.057	0.057
Lentibulariaceae	*Utricularia vulgaris*	0.088	0.088
Salviniaceae	*Salvinia natans*	0.045	0.045
Gentianaceae	*Ipomoea pubescens*	0.031	0.031
Najadaceae	Microalgae	0.038	0.038
Cyperaceae	*Scirpus tabernaemontani*	0.01	0.02
	Scirpus triqueter	0.01	
Lemnaceae	Azolla	0.01	0.01

Table 8
Important values of aquatic plants in island lakes and wetlands of scenic spots in autumn

Family name	Species name	Important value	Family importance
Potamogetonaceae	*Potamogeton pectinatus*	0.147	0.147
Hydrocharitacea	Water turtle	0.079	0.107
	Hydrilla verticillata	0.028	
Ceratophyllaceae	*Hydrilla verticillata*	0.227	0.227
Nymphaeaceae	*Nelumbo nucifera*	0.252	0.268
	Nymphaea tetragona	0.016	
Salviniaceae	*Salvinia natans*	0.053	0.053
Pteridiaceae	Azolla	0.022	0.022
Gentianaceae	*Nymphoides peltatum*	0.032	0.032
Najadaceae	*Najas minor*	0.02	0.02
Lentibulariaceae	*Utricularia vulgaris*	0.026	0.026
Haloragidaceae	*Myriophyllum spicatum*	0.021	0.021
Gramineae	*Phragmites communis*	0.173	0.173
Typhaceae	*Typha angustifolia*	0.121	0.121
Amaranthaceae	*Alternanthera philoxeroides*	0.024	0.024

and the dominant communities changed in spring, summer, and autumn. The dominant communities of S16 and S17 were mainly lotus in summer and autumn. In S18 and S19, the mixed communities of *C. demersum* and other species were dominant species [19]. There were different dominant communities in the three seasons of S27, but there were *Potamogeton ricini* in all of them, which indicated that *P. Castanea* had obvious advantage in this sample site. In S28, the dominant communities of *C. demersum* were obvious, and the three seasonal dominant communities were mixed communities of *C. demersum* and other species [20–22].

4. Conclusion

In this paper, 30 sample sites of Island Lake Wetland in tourist attractions were selected to investigate the distribution of plants in the lake wetland, and the plant communities in different seasons were analyzed:

- In 2019, a total of 24 species of aquatic plants were investigated in the islands of tourist attractions, which were distributed in 14 families. *P. crispus*, lotus, and *C. demersum* were the dominant species. Due to the limited conditions of field investigation, there may be many uncertain factors,

Table 9
Classification of aquatic plant communities in different seasons

Sampling point	Spring community	Summer community	Autumn community
S1 scenic spot 1a	*Potamogeton crispus* community	*Nelumbo nucifera* + *Ceratophyllum demersum*	*Nelumbo nucifera* + *Ceratophyllum demersum* community
S2 scenic spot 1b	Nothing	Lotus community	Lotus community
S3 scenic spot 2	*Potamogeton crispus* + Lotus community	Lotus community	Lotus community
S4 scenic spot 3	*Potamogeton crispus* community	Community of Potamogeton castor	Community of Potamogeton castor
S5 scenic spot 4	*Myriophyllum spicatum* + Lepidium community	Community of Potamogeton castor	Community of Potamogeton castor
S6 scenic spot 5	*Potamogeton crispus* community	*Potamogeton crispus* community	*Potamogeton pectinatus* + *Ceratophyllum demersum* + water turtle community
S7 scenic spot 6	*Potamogeton crispus* community	*Potamogeton pectinatus* + *Ceratophyllum demersum* + water turtle community	*Phragmites communis* + Typha + Lotus community
S8 scenic spot 7	*Potamogeton crispus* + community of Potamogeton castor	*Nelumbo nucifera* + community of Potamogeton castor	*Nelumbo nucifera* + community of Potamogeton castor
S9 scenic spot 8	*Potamogeton crispus* + *Myriophyllum spicatum* community	*Myriophyllum spicatum* community	*Myriophyllum spicatum* community
S10 scenic spot 9	*Potamogeton crispus* + *Ceratophyllum demersum* community	*Myriophyllum spicatum* community	Community of Potamogeton castor
S11 scenic spot 10	*Potamogeton crispus* community	*Phragmites australis*	*Phragmites communis* + Typha + Lotus community
S12 scenic spot 11	*Potamogeton crispus* + Lotus community	*Ceratophyllum demersum* + community of Potamogeton castor	*Potamogeton pectinatus* + *Ceratophyllum demersum* + water turtle community
S13 scenic spot 12	Nothing	Nothing	Hydrocharis dubia + *Ceratophyllum demersum* community
S14 scenic spot 13	Nothing	Nothing	Nothing

S15 scenic spot 14	*Potamogeton crispus* community	*Potamogeton pectinatus* + *Phragmites australis*	*Utricularia vulgaris* + microcystis community
S16 scenic spot 15	Nothing	Lotus community	*Nelumbo nucifera* + *Ceratophyllum demersum* community
S17 scenic spot 16	Nothing	*Nelumbo nucifera* + *Hydrocharis dubia* + *Ceratophyllum demersum* community	*Nelumbo nucifera* + *Hydrocharis dubia* + *Ceratophyllum demersum* community
S18 scenic spot 17a	Nothing	*Ceratophyllum demersum* community	*Nelumbo nucifera* + *Ceratophyllum demersum* community
S19 scenic spot 17b	Nothing	*Ceratophyllum demersum*	*Ceratophyllum demersum* + *Sophora japonica* community
S20 attractions 18	Nothing	Nothing	Nothing
S21 attractions 19	Nothing	*Hydrocharis dubia* + Cattail community	*Ceratophyllum demersum* + Lotus community
S22 attractions 20	Nothing	Nothing	Nothing
S23 scenic spots 21a	Azolla community	*Nelumbo nucifera* + *Hydrocharis dubia* + community of Potamogeton castor	*Nelumbo nucifera* + *Salvinia natans* + Azolla community
S24 scenic spots 21b	Azolla community	*Nelumbo nucifera* + *Hydrocharis dubia* + community of Potamogeton castor	*Nelumbo nucifera* + *Salvinia natans* + Azolla community
S25 scenic spots 21c	Azolla community	*Nelumbo nucifera* + *Hydrocharis dubia* + community of Potamogeton castor	*Nelumbo nucifera* + *Salvinia natans* + Azolla community
S26 scenic spots 21d	Azolla community	*Nelumbo nucifera* + *Ceratophyllum demersum* community	*Salvinia natans* + Azolla community
S27 scenic spots 22	*Potamogeton pectinatus* + *Ceratophyllum demersum* + water turtle community	*Nelumbo nucifera* + *Potamogeton pectinatus*	*Potamogeton pectinatus* + Lotus community
S28 scenic spots 23	*Ceratophyllum demersum* + water turtle community	*Salvinia natans* + *Ceratophyllum demersum* + *Hydrocharis dubia*	*Ceratophyllum demersum* + *Sophora japonica* community
S29 scenic spots 24	*Potamogeton crispus* + Lotus community	Nothing	*Ceratophyllum demersum* + *Salvinia natans* + water turtle community
S30 scenic spots 25	Community of Potamogeton castor	Nothing	Lotus community

as well as the insufficient setting of survey sample points and the insufficient investigation scope. In addition, the identification level of aquatic plants is not enough, which leads to the problem that the aquatic plants investigation in scenic islands is not comprehensive enough. Therefore, the species and number of aquatic plants in the islands of tourist attractions are shown in the survey results. There are some errors in quantity and distribution.

- There are differences in plant growth and distribution in different seasons. According to the field survey and statistics, the island plant communities in the scenic spots are *P. crispus* community, lotus community, *C. demersum* community, Potamogeton communis community, *M. spicatum* community, *C. demersum* + water turtle community, *Sophora japonica* + Azolla community, etc. In different seasons, the dominant communities in the islands are different. The dominant communities are *P. crispus* in spring, and lotus and *C. demersum* communities in summer and autumn. The dominant degree of community distribution in different areas was also different. For example, the community of *M. spicatum* was the main community in S9.

Aquatic plants play an important role in wetland ecosystem, so its protection is particularly important. The protection of aquatic plants in island lakes and wetlands in tourist attractions can be carried out from the following aspects:

- In view of the scenic spots close to the village residential areas, the reasonable guidance for the discharge of domestic sewage should be considered to prevent the formation of large-area runoff, which will make the water quality worse. Aquatic plants with water purification function should be designed and planted, and the water body should be purified by biological action, so that the aquatic plants can be gradually recovered.

For the seriously eutrophic scenic spots, we can design and plant some plants with phosphorus removal function, such as *T. angustifolia*, *Allium fistulosum*, etc. For the scenic spots with low transparency, some species with low light compensation point should be restored first, such as *M. spicatum*, *Vallisneria*, dactylum, etc., and the first recovered species should be monitored for their growth. If their growth is stable, the species can be gradually enriched. In the process of ecological restoration, submerged macrophytes in aquatic plants play an important role in water quality and environment. The dominance of submerged plants should be strengthened to facilitate the better recovery of water and aquatic plants.

- The deterioration of water quality is one of the reasons for the growth and degradation of aquatic plants. Therefore, it is of great significance to monitor the water quality, especially the continuous detection, in the island areas of tourist attractions. It is necessary to put forward practical and feasible schemes to effectively control water pollution, so as to improve the quality of aquatic plants in island lakes and wetlands for better growth and living environment.
- To strengthen the control of fisheries, the survey found that in the aquaculture area, the species, and quantity of aquatic plants are very few, and the fishing in the aquaculture area has great destructive effect on aquatic plants, especially submerged plants, so we should strengthen the management and control of fisheries in the aquaculture area.
- Strengthen the regulation and management of water level and water storage capacity in the scenic area. The water level will affect the growth of aquatic plants, and some plants will be submerged and die due to high water level. Therefore, the water level is also very important for the protection and restoration of aquatic plants.

Acknowledgments

The research is supported by: "Ph.D. and Professor Fund Project of Guilin University of Aerospace Technology, China"; "Low-altitude Tourism Industry Development Research Base Project of Guilin University of Aerospace Technology, China".

References

[1] H. Heather, K.A. Moore, L.A. Gettys, Growth of the aquatic plant southern naiad in varying percentages of sand and controlled-release fertilizer, Horttechnology, 28 (2018) 252–256.
[2] D.Q. Zhang, M. Wang, Q. He, X. Niu, Y. Liang, Distribution of perfluoroalkyl substances (PFASs) in aquatic plant-based systems: From soil adsorption and plant uptake to effects on microbial community, Environ. Pollut., 257 (2019) 113575, doi: 10.1016/j.envpol.2019.113575.
[3] R. Bolpagni, A. Laini, C. Stanzani, A. Chiarucci, Aquatic plant diversity in italy: distribution, drivers and strategic conservation actions, Front. Plant Sci., 9 (2018), doi: 10.3389/fpls.2018.00116.
[4] L. Adamec, Ecophysiological characteristics of turions of aquatic plants: a review, Aquat. Bot., 148 (2018) 64–77.
[5] S.A. Kurbatova, Z.M. Mylnikova, I.Y. Yershov, S.N. Bykova, O.G. Vinogradova, Influence of aquatic plants of different ecological groups on zooplankton distribution and abundance, Contemp. Probl. Ecol., 11 (2018) 45–53.
[6] N. Vila-Martínez, N. Caiola, C. Ibáñez, LluisBenejam, S. Brucet, Normalized abundance spectra of fish community reflect hydro-peaking on a Mediterranean large river, Ecol. Indic., 97 (2019) 280–289.
[7] P. Barua, S.H. Rahman, S. Barua, I.M.M. Rahman, Climate change vulnerability and responses of fisherfolk communities in the south-eastern coast of Bangladesh, Water Conserv. Manage., 4 (2020) 20–31.
[8] Z.N. Fogwe, S.J.P. Tume, M. Fouda, Eucalyptus tree colonization of the Bafut-Ngemba forest reserve, north west region, Cameroon, Environ. Ecosyst. Sci., 3 (2019) 12–16.
[9] S.N.M. Ali, M.F. Kammoo, N.N.N. Ali, M.F. Miskon, Distribution pattern of rare earth elements in soft tissue of *Saccostrea cucullata* in Terengganu and east Johor Coastal water, J. Clean WAS, 3 (2019) 14–19.
[10] B. Zhou, T. Tu, F. Kong, J. Wen, X. Xu, Revised phylogeny and historical biogeography of the cosmopolitan aquatic plant genus Typha (Typhaceae), Sci. Rep., 8 (2018) 8813–8819.
[11] S.H. Seo, M.H. Son, E.S. Shin, S.-D. Choi, Y.-S. Chang, Matrix-specific distribution and compositional profiles of perfluoroalkyl substances (PFASs) in multimedia environments, J. Hazard. Mater., 364 (2019) 19–27.
[12] Z. Yang, J. Huang, X. Duan, J. Zhang, X. Zhou, Distribution characteristics of coking products and mechanism of tar lightening in preparation of high-strength gasification-coke with low-rank coal blending, Energy Fuels, 33 (2019) 10904–10912.

[13] R. Li, L. Yu, M. Chai, H. Wu, X. Zhu, The distribution, characteristics and ecological risks of microplastics in the mangroves of Southern China, Sci. Total Environ., 708 (2019) 135025, doi: 10.1016/j.scitotenv.2019.135025.
[14] T.N.F. Roach, J. Nulton, P. Sibani, F. Rohwer, P. Salamon, Emergent structure in a stochastic model of ecological evolution, Ecol. Modell., 401 (2019) 129–133.
[15] Z. Zhang, S. Xu, C. Capinha, R. Weterings, T. Gao, Using species distribution model to predict the impact of climate change on the potential distribution of Japanese whiting *Sillago japonica*, Ecol. Indic., 104 (2019) 333–340.
[16] A. Abadie, M. Pace, S. Gobert, J.A. Borg, Seascape ecology in *Posidonia oceanica* seagrass meadows: linking structure and ecological processes for management, Ecol. Indic., 87 (2018) 1–13.
[17] A. Gaberik, J.L. Krek, I. Zelnik, Habitat diversity along a hydrological gradient in a complex wetland results in high plant species diversity, Ecol. Eng., 118 (2018) 84–92.
[18] C. Ferrara, L. Salvati, P. Corona, R. Romano, M. Marchi, The background context matters: local-scale socioeconomic conditions and the spatial distribution of wildfires in Italy, Sci. Total Environ., 654 (2018) 43–52.
[19] F. Gu, J. Guo, W. Zhang, P. Summers, P. Hall, From waste plastics to industrial raw materials: a life cycle assessment of mechanical plastic recycling practice based on a real-world case study, Sci. Total Environ., 601 (2017) 1192–1207.
[20] Q. Quan, H. Zou, X. Huang, J. Lei, Research on water temperature prediction based on improved support vector regression, Neural Comput. Appl., 32 (2020), doi: 10.1007/s00521-020-04836-4.
[21] G.O. Erguven, H. Bayhan, B. Ikizoglu, G. Kanat, G. Demir, Removal rate of herbicide aclonifen with isolated bacteria and fungi, Appl. Ecol. Environ. Res., 14 (2016) 351–365.
[22] Y. Joute, H. El Bari, S. Belhadj, F. Karouach, Y. Gradi, W. Stelte, A.B. Bjerre, Semi-continuous anaerobic co-digestion of cow manure and banana waste: effects of mixture ratio, Appl. Ecol. Environ. Res., 14 (2016) 337–349.