Study on effects of exploitation of tourism resources on natural ecological environment of Yuntaishan Geopark and its solutions

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Abstract: Exploitation of tourism resources has various effects on the natural ecological environment. This paper has investigated Yuntaishan Geopark through literature research, field investigation and data analysis to analyze the influence of tourism development on the natural ecological environment, including the air, soil, water and biological environment on the basis of the overview of Yuntaishan Geopark's tourism resources, development and the status quo of natural ecological environment. The study revealed that with the tourism development of Yuntaishan Geopark, the environmental quality in tourism areas was deteriorating and the tourism resources were also seriously damaged. Therefore, the paper put forward solutions for reasonable exploitation of the tourism resources, protection of the natural ecological environment and seeking better, faster and more harmonious tourism development of Yuntaishan Geopark.

Keywords: Yuntai Mountain; geopark; exploitation of tourism resources; natural ecological environment

1 Introduction

Yuntaishan Geopark (112°44′40″E~113°26′45″E, 35°11′25″N~35°29′40″N), covering an area of 556 km², is located in the south of Taihang Mountain and north of Jiaozuo in Henan Province, 30 km away from the downtown of Jiaozuo and 98 km away from Zhengzhou, the provincial capital of Henan Province. The Geopark which is mainly characterized by rifting structures, hydrodynamic processes and geological physiognomy landscape and also featured by natural ecological and human landscapes comprises five parks: Yuntai Mountain Park, Shennong Mountain Park, Qingtian River Park, Qinglong Valley Park and Fenglin Valley Park. Yuntaishan Geopark consists of the complete marine environment from the Mesoproterozoic Era and Paleozoic Era, especially the epicontinental sea sedimentation, characterizing the Yuntai Landform.
which is distinct from the karst landform in the south of China (Wang et al, 2007). In addition, there are diverse biocenoses with more than 93% of the vegetation coverage rate, over 1400 species of plants and more than 400 species of animals. The abundant tourism resources in Yuntaishan include four categories and 17 kinds, accounting for 25% of the 68 basic kinds nationwide.

2 Overview of the exploitation of tourism resources in Yuntaishan Geopark

2.1 Analysis of tourism resources

2.5 billion years ago, namely, in the late Archean, Songyang Movement made the crust of Yuntaishan growing into the crystalline basement. In the Mesoproterozoic Era, this area began to rise and fall. During the period of sinking, the coastal environment formed and a large amount of terrigenous clastic sediments were accepted then the quartz sandstone appeared near Wenpan Valley and Baijiayan. During the late Mesozoic Era to early Cretaceous, with the subduction and interaction of the Pacific Plate to the Asian Plate, the East Asian rift system formed due to large-scale rifting and uplifting in the east of the North China plate. Because of the piedmont fault zone of Taihang Mountain, in the Himalaya orogeny, the Yuntai Landform consisted of cliffs in the shapes of zigzag, line, circle and steps, urn valleys, deep gorges and hanging valleys appeared in the area around Yuntai Mountain, shaping into deep and serene valleys, high and steep mountains, vast waterfalls and clear springs, which are important to study the neotectonic movement and the evolution of rifts.

Geological landscape of Yuntaishan Geopark is mainly characterized by structural cuesta and cliffs, waterfalls, valleys and springs. The Yuntai Landform was made mainly by the tectonics (Table 1) (Fan, 2004), which shaped special landscape with the natural erosion, which is not only of high value for scientific research, but also of great aesthetic value (Figure 1).

| Table 1 | Classification of geological-geomorphological landscape of Yuntaishan Geopark |
| Category | Basic type |
| Geomorphological landscape | Ridge, cliff, wall, isolated peak, peak cluster, peak forest, pictographic stone, ravine, gorge, urn valley, depression of glacial erosion, hanging valley |
| Sedimentary relics | Stratigraphic section, sedimentary structure, fossil, travertine, sinter |
| Tectonic relics | Tectonic profile, fault, joint, fracture, collapsed block accumulation |
| Special ore and mineral waterscape | Oolitic limestone, pisolite limestone, oncolite limestone, algal reef (callenia) limestone |
| | Waterfall, drop, pond, spring, lake |

The scenic area of Yuntaishan Geopark is in deciduous broad-leaved forest in warm temperate zone (Wu, & Wang, 1983), but boreal forest could also be found in the elevation. The original vegetation is the natural secondary forest. Under the effects of climate and soil, there are various plants. According to incomplete statistics, there are 1492 species of 195 families of higher plants in Yuntaishan Geopark, including 73 species of 33 families of bryophytes; 80 species of 20 families of ferns; 12 species of 4 families of gymnosperms; 1327 species of 138 families of angiosperms. Thousand years old Chinese yew (Taxus chinensis (Pilger) Rehd.) which is in the National Key
Protected Wild Plants List, thousand years old Chinese elm (*Ulmus parvifolia* Jacq.) and mono maple (*Acer pictum* subsp. *mono*) could be found here (Jiang et al, 2007). In addition, there are more than 400 species of animals in Yuntai Mountain, including mammals, reptiles, fishes, birds and insects among which the *Macaca mulatta* is the National Second Class Protected Animal and the *Craspedacusta* is a national endangered wildlife (Figure 2).

**Figure 1**  Ripple mark stone of quartz sandstone of Yuntaishan Zone

**Figure 2**  *Macaca mulatta* in Taihang Mountain

### 2.2 Overview of tourism development

In 2004, Yuntai Mountain was listed in the first Global Geoparks by UNESCO. Since then, the scale of the tourism has been expanding. As of 2016, the radius of tourism market has reached 1500 kilometers, and the number of tourists has steadily increased to 5.3 million/year. For Yuntaishan Geopark, sightseeing is still the mainstream of tourism with most tourists staying in the scenic area for only one day.

Yuntai Mountain is the representative of the northern mountain tourist attractions. Affected greatly by the climate, the characteristics of the tourist season are obvious, more visitors in April and May for spring outing and July and August for trip of summer vacation. In particular, in holidays for International Labor Day, Qingming Festival, Dragon Boat Festival and National Day and other statutory holidays, visitors
to Yuntaishan would peak. During the tourist season, the average daily number of tourists is about 10,000-20,000 from Monday to Friday while that is 30,000-50,000 in the weekend. The highest volume of tourist reception in one day was 100,000. According to the results of calculating the environmental carrying capacity of Yuntai Mountain, the optimal daily environmental capacity is 13,000 visitors, and the maximum daily environmental capacity is 26,000 (Chang, & Sun, 2009). During the tourist season, the daily number of tourists would often exceed the maximum daily environmental capacity due to excessive concentration of visitors which will have serious impacts on the local ecological environment.

3 Influence of exploitation of tourism resources on natural ecological environment of Yuntaishan Geopark

The tourism resources mountain are of high sensitivity and environmental sensitivity (Li, Wang, & Cheng, 2010), so improper development would easily cause the destruction of resources. The tourism development of Yuntai Mountain brings economic benefits and increases employment for the region, but its interference to the tourism resources is increasing, which poses a serious threat to the environment quality, biodiversity and tourism resources in the area.

3.1 Atmospheric environment

Before extensive exploitation of Yuntaishan Mountain, it was inaccessible and rarely disturbed. After the establishment of the Geopark, with the rapid development of tourism, the reception facilities and vehicles in the park have increased greatly, resulting in a lot of living waste gas and deterioration of the air quality in the park. The pollution comes mainly from tourist facilities and vehicles. Catering and heating systems such as LPG, oil burning boiler and coal fired common-pressure boiler discharge gases and vehicles raise dust and discharge exhaust gases. A large number of visitors would also have a little influence on the air quality due to their exhaled air.

The air pollution can be quantified with the concentration of PM 2.5. PM 2.5 refers to the particulate matter whose aerodynamic equivalent diameter less than or equal to 2.5 microns in the ambient air. It can be suspended in the air for a long time, and the higher concentration in air means the more serious air pollution. In the process of heating and cooking, the soot emitted through firing coal and gas or fuel and the exhaust gas emitted by various vehicles would greatly increase the concentration of PM 2.5. Before the exploitation of Yuntaishan Geopark, the air quality was good with low concentration of PM 2.5. During May 12-14, 2016 in the tourist season, PM 2.5 was detected twice a day for three days in Baijiayan, Hongshi Valley, Xiaozhaigou and Zhuyu Peak and the detected concentration of PM 2.5 was about 24 μg/m³, approaching 25 μg/m³, the upper limit of average daily concentration of PM 2.5 confirmed in 2005 Air Quality Guidelines by WHO, which reveals that the air quality of Yuntaishan Geopark has been greatly disturbed by the exploitation of tourism resources.

3.2 Soil environment

The soil of Yuntaishan Geopark consists of brown earths and cinnamon soil. Brown earths with the soil thickness of 50 – 60 cm, heavy texture and slight acidity to neu-
trality could be found in the northern mountain area at the altitude of 800 – 1000 meters. PH value is about 6.5 – 7. Because of the large scale vegetation coverage, rich organic matter and raininess, the natural fertility is high. Cinnamon soil with the soil thickness of 20 – 30 cm, light texture or medium, 30% – 60% of gravel and neutrality to slight alkalinity could be found in hilly areas. PH value is about 7 – 7.5. The parent material is slope deposits or flood deposits and some loess could be found in the lower part of the valley. The cinnamon soil area has stony and thin soil layer and the erosion is serious, so the rocks in some sections are exposed. A large number of tourists entering the park in a short time and the increasing intensity of tourism development will affect the soil structure and soil environment.

Studies on physicochemical properties of soil in the background area, buffer area and the core area of the peak, mountainside and foot of Yuntai Mountain under different disturbance intensity of tourism revealed that with the increasing disturbance of tourism, the soil porosity, soil moisture and soil nutrient mainly including organic matter and compounds of nitrogen, phosphorus and potassium all have decreased and PH value of the soil has increased (Cao, 2015). This is because the tourists stamp the paths especially both sides of the pathways and roll the soil, resulting in the soil hardening and increasing of soil compactness; with the construction of a large number of infrastructure and tourism facilities, roads, parking lots, necessary tourism facilities and service facilities occupy the green land and destroy the vegetation, resulting in the increasing bare soil and decreasing plant litter, at the same time, the destruction of vegetation causes soil erosion and decreases organic matter, organic acid and inorganic acid in the soil; waste in soil, especially the drink splashed into it, increases the PH value of soil; untreated sewage and solid waste are piled up on the soil surface, harmful waste water and harmful substances continue to permeate the soil, dust and harmful gases in the air fall into the soil with the rain, which all result in soil pollution; the destruction of vegetation causes soil erosion, increasing bare soil area and worse soil quality (Table 2).

Table 2  Characters of soil under different treatments (Cao, 2015)

<table>
<thead>
<tr>
<th>Location</th>
<th>Treatment</th>
<th>Moisture content/%</th>
<th>Porosity/%</th>
<th>Organic matter/(g/kg)</th>
<th>Total nitrogen/(g/kg)</th>
<th>Total phosphorus/(g/kg)</th>
<th>Total potassium/(g/kg)</th>
<th>pH value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>Core area</td>
<td>7.62</td>
<td>56.22</td>
<td>39.52</td>
<td>1.63</td>
<td>1.51</td>
<td>8.17</td>
<td>7.28</td>
</tr>
<tr>
<td></td>
<td>Buffer area</td>
<td>8.96</td>
<td>58.11</td>
<td>50.35</td>
<td>2.05</td>
<td>1.72</td>
<td>8.95</td>
<td>6.81</td>
</tr>
<tr>
<td></td>
<td>Background area</td>
<td>10.21</td>
<td>60.75</td>
<td>55.58</td>
<td>2.29</td>
<td>1.86</td>
<td>9.12</td>
<td>6.63</td>
</tr>
<tr>
<td>Foot</td>
<td>Core area</td>
<td>5.72</td>
<td>50.94</td>
<td>27.54</td>
<td>1.37</td>
<td>1.21</td>
<td>7.13</td>
<td>7.76</td>
</tr>
<tr>
<td></td>
<td>Buffer area</td>
<td>7.26</td>
<td>53.58</td>
<td>34.26</td>
<td>1.62</td>
<td>1.40</td>
<td>8.76</td>
<td>7.32</td>
</tr>
<tr>
<td></td>
<td>Background area</td>
<td>7.56</td>
<td>55.47</td>
<td>36.26</td>
<td>1.73</td>
<td>1.42</td>
<td>8.91</td>
<td>7.10</td>
</tr>
<tr>
<td>Mountainside</td>
<td>Core area</td>
<td>4.12</td>
<td>49.06</td>
<td>11.65</td>
<td>0.53</td>
<td>0.51</td>
<td>7.26</td>
<td>8.67</td>
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<tr>
<td></td>
<td>Buffer area</td>
<td>4.37</td>
<td>52.70</td>
<td>12.16</td>
<td>0.58</td>
<td>0.54</td>
<td>7.62</td>
<td>8.38</td>
</tr>
<tr>
<td></td>
<td>Background area</td>
<td>5.22</td>
<td>53.96</td>
<td>19.02</td>
<td>0.89</td>
<td>0.72</td>
<td>8.53</td>
<td>7.98</td>
</tr>
</tbody>
</table>

3.3 Water environment

During the dry season, the water supply in Yuntai Mountain mainly depends on spring water, while during the wet season that depends on rainfall and spring water. With the increasing number of tourists, hotels and restaurants, the water consumption has
been increasing, which undoubtedly brings pressure on the water supply. Tourism development such as construction of tourism facilities along the stream changes the waterfront environment and continuously disturbs the water. Moreover, tourists’ wading and dabbling directly affect the water. The increasing sewage has become a potential contamination for the water. Incomplete sewage system and ineffective wastewater treatment lead to the pollutants including a variety of organic matter, solids, suspended solids, oil, all kinds of humic matter and toxic heavy metal compounds being discharged into the water. With the pollutants in the water, the waterscape quality would be affected firstly; the groundwater quality would be affected through the infiltration effect then the safety of drinking water would be impaired; lastly the living environment of aquatic animals and plants would also be changed. In addition, the tourism development in the upper reaches has different impacts on the water quality in the lower reaches of the scenic area.

The water samples were taken from main scenic spots of Yuntaishan Geopark with the below figure showing the transect of sampling points (Figure 3). The monitoring data revealed that the total nitrogen during dry season and wet season seriously exceeded the standard and the total coliform was significantly higher (Table 3). Especially in the dry season, the data about coliform in the scenic spots with numerous tourism activities was significantly higher than that of Fenglinxia Reservoir (formerly Quyinghu Reservoir) which attracts less visitors (Table 4). Generally speaking, the total ammonia in sewage is often found to be excessive and coliform bacteria is always found in the feces of warm blood animals, sites with various human activities and places with fecal pollution. Therefore the effects of tourism activities on the water environment in scenic area has been verified.

![Figure 3 Transect of sampling points for surface water](image)

### 3.4 Biodiversity

Tourists’ carving and painting on the trees, over-felling and destroying during construction of the scenic spots, harm from atmospheric pollutants to plants and invasive
species all greatly affect the vegetation in Yuntaishan Geopark. In the process of the construction, roads, parking lots, tourism infrastructures and supporting facilities occupy a lot of land, which not only affects the vegetation coverage, but also directly decreases the number of local plant species. With the tourism development, the vegetation has been destroyed; roads, parking lots, tourist routes and various infrastructures occupied the green land and tourists' man-made destruction including trampling and burning destroyed the vegetation in the scenic area, therefore the biodiversity, the ecological structure and biological reproduction are seriously damaged and the overall function declines.

During the sightseeing, tourists often feed animals like macaques which results in
animals depending on tourists' feeding instead of finding food in the nature; in addition, garbage in the reception area and waste left in the field by visitors after overseeing often attract rodents and insects come to eat, which changes their feeding habits. Moreover, in the long run, the scare and disturbance to animals also reduce the animal population. For endangered species, such disturbance would have a greater impact on population.

4 Countermeasures on management of Yuntaishan Geopark

The ecological environment is the basis of tourism development. The good ecological environment would have a great attraction for tourists while environmental deterioration would lead to recession and decline of tourism. The previous analysis revealed that the exploitation of tourism resources has caused serious pollution and damage to the natural ecological environment of Yuntaishan Geopark. Therefore, it's urgent and necessary to take practical measures for environmental management and control to solve the problems on ecological environment of the park.

As a whole, Yuntaishan Geopark should be developed moderately and gradually according to the plan year by year. The essence of relationship between the development scale of the geopark and environmental capacity is that between the requirement for development of geological tourism and the park's own capacity. If the scale of the tourism is less than the environmental capacity, the landscape resources could be developed further due to its incomplete development, in which case the oversupply would be conducive to protect the landscape resources. If the amount of visitors approaches to the environmental capacity, the park tends to be saturated, in which case the development should be suspended to remain the balance. If the amount of visitors exceeds the environmental capacity, the park would be overexploited, in which case demand exceeds supply and landscape resources and facilities in the park would be destroyed, then the amount of visitors should be limited or the further development of new scenic spots, new attractions and new facilities should be suspended. During the tourist season of Yuntaishan Geopark, the number of visitors is far more than the optimum daily environmental capacity. The park covers an area of 500 km² with high quality landscape area, but many scenic spots still being in original state without any development. Proper development of scenic spots could disperse the visitors to avoid increasing burden on the environment due to visitors' concentration in the vicinity of some attractions. But the scope and scale of development should be properly limited so as to avoid the overall impact of tourism on the entire environment of Yuntai Mountain.

In order to relieve the influence of the tourism development on the air, soil and water, all restaurants should be forbidden to cook and only instant foods are allowed to supply. All rubbish should be treated out of the park. Burning coal and burning grass are forbidden and clean energy like electricity, gas and solar energy should be used in traffic. Land cultivation is only allowed in the transition zone on the edge. Special cleaning teams shall be set up to keep the park clean and to remove waste on roads and the water surface. Feces in the public toilets should be specially collected and moved out of the scenic area.

As for the vegetation and ecological conditions of Yuntai Mountain, the forest coverage rate is low and the ecological environment is fragile. Rare animals and plants
like *Craspedacusta*, *Macaca mulatta*, *Pinus bungeana* Zucc. and *Zelkova serrata* (Thunb.) Makino could survive in the park for a long-term due to the special ecological environment of the park. Human interference and destruction could affect the maintenance of the original ecology greatly and even lead to the disappearance of these species. It also requires that foreign species should not be introduced blindly. In order to reduce the dependence of wild animals on tourists' feeding and garbage and enhance their ability of finding food in the wild, tourists' feeding should be gradually forbidden and waste should be collected timely.

At present, the tourists' behavior has the most obvious influence on the environmental quality of the park. We should improve visitors' awareness of environmental protection and enhance social morality education and safety education to them. More signage and warning signs should be set to remind visitors not to litter or smoke, and to guide visitors to the prevention of forest fire and protection of ecological environment.

5 Conclusions

Yuntaishan Geopark is one of the first world geopark in China. Since its establishment, the tourism has developed rapidly. But at the same time, the huge amount of tourists has changed the park’s environment quality. The vegetation, air and water in some areas of the park have been polluted and damaged in varying degrees. Solving these problems is the key to the sustainable development of the tourism of Yuntaishan Geopark, which requires the proper planning and management as well as regulation of tourists' behaviors.

Acknowledgement

Thanks for support and assistance from Center of Education for Geography and Sustainable Development, Beijing Normal University.

References


