# Evaluation and Regulation Strategies for Human Disturbances in Urban Parks Based on the Nitrogen Cycle

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**Abstract**

This article focuses on the nitrogen cycling process within urban park ecosystems and thoroughly examines the disturbances caused by human activities. It first elaborates on the crucial role of nitrogen cycling in urban park ecology, then analyzes the main manifestations and causes of human disturbances. Subsequently, an assessment system for human disturbances is constructed, quantifying the degree of disturbance from multiple perspectives. Finally, based on the assessment results, targeted control strategies are proposed, aiming to achieve sustainable development of urban park ecosystems and provide theoretical support and practical guidance for urban ecological construction.

**Keywords:** Nitrogen Cycle; Urban Park; Human Disturbance; Evaluation System; Regulatory Strategy

## 1. Introduction

Urban parks, as an indispensable part of the urban ecosystem, fulfill multiple important functions. They are not only ideal places for urban residents to relax and enjoy nature, but also play an irreplaceable role in regulating the urban climate, purifying the air, and conserving water sources [1]. In the ecosystem, nitrogen cycling is one of the core links of the material cycle, playing a crucial supporting role in maintaining the stability and normal functioning of the ecosystem. The status of nitrogen cycling in urban parks directly affects the growth of vegetation, the quality of soil, and the overall health level of the ecosystem [2].

With the accelerated urbanization process and the continuous expansion of urban scale, as well as the increasing population density, human activities have become more frequent and intense in urban parks [3]. This interference inevitably has a significant impact on the nitrogen cycling in urban parks, threatening the balance and stability of the park ecosystem. For example, industrial exhaust emissions, vehicle exhaust emissions, and unreasonable agricultural activities all lead to a large amount of nitrogen-containing pollutants entering the urban environment, which eventually enter urban parks through atmospheric deposition and surface runoff [4]. The input of these nitrogen-containing pollutants disrupts the original nitrogen balance in the park and has a negative impact on the biological communities and ecological processes within the park.

The assessment and regulation strategies for human disturbances in urban parks based on nitrogen cycling have extremely important practical significance. From an ecological perspective, understanding the impact of human disturbances on nitrogen cycling helps us take effective measures to protect the ecosystem of urban parks, maintain biodiversity, and promote the health and sustainable development of the ecosystem [5]. From a social perspective, a healthy urban park ecosystem can provide urban residents with a better leisure and entertainment environment, improve the quality of life of residents, and enhance their sense of happiness and belonging [6] .From an economic perspective, urban parks, as important infrastructure of the city, the normal functioning of their ecological functions can reduce the costs of environmental governance and climate regulation in the city, and have significant economic benefits [7].

## 2. The Key Role of Nitrogen Cycling in Urban Park Ecosystems

Nitrogen cycling is a crucial part of the biogeochemical cycle on Earth, involving complex transformations and migrations of nitrogen elements between the biosphere, atmosphere, lithosphere, and hydrosphere. In the relatively independent yet closely interconnected specific environment of urban park ecosystems, nitrogen cycling follows the basic biogeochemical laws, but also has its unique manifestations and mechanisms.

The nitrogen cycling in urban parks mainly includes key processes such as nitrogen fixation, ammonification, nitrification, and denitrification. Nitrogen fixation is the process of converting inert nitrogen in the atmosphere into nitrogen compounds that are biologically available, providing necessary nitrogen sources for the growth of plants in the park. Plants absorb these nitrogen compounds through their roots and use them to synthesize important biological molecules such as proteins and nucleic acids, thereby promoting their growth and development.

Ammonification is the process of decomposing organic nitrogen into ammonia. Microorganisms in the soil play an important role in this process. Nitrification further oxidizes ammonia into nitrate and nitrite, which are more easily absorbed and utilized by plants. Denitrification then reduces nitrate to nitrogen gas, releasing it into the atmosphere and completing a complete cycle of nitrogen cycling. These processes are interrelated and mutually influential, jointly maintaining the nitrogen balance of the urban park ecosystem.

A reasonable nitrogen cycle can provide sufficient nutrients for plants, promote lush growth of vegetation, and increase plant biomass and productivity. Healthy vegetation not only beautifies the urban environment but also absorbs carbon dioxide,

releases oxygen, regulates the urban climate, and reduces the heat island effect. At the same time, vegetation can adsorb dust and pollutants in the air, playing a role in air purification. Moreover, nitrogen cycling is closely related to soil fertility and microbial activities. Appropriate nitrogen content can maintain soil fertility, provide a favorable living environment for soil microorganisms, and promote their growth and reproduction. Soil microorganisms play an important role in decomposing organic matter, fixing nitrogen, and other aspects, and their activities further enhance the ecological functions of the soil, providing a solid guarantee for the stable operation of the urban park ecosystem [8].

## 3. Main Manifestations and Causes of Human Disturbances in Urban Parks

The main manifestations of human disturbances in urban parks are diverse. Among them, the increase in nitrogen input is one of the most prominent issues. With the rapid development of industrialization and urbanization, a large amount of nitrogen-containing pollutants are discharged into the atmosphere. These pollutants enter urban parks through dry and wet deposition.

Nitrogen oxides in industrial exhaust gases, and nitrogen-containing compounds in vehicle exhausts, undergo a series of chemical reactions in the atmosphere and fall to the park ground in the form of acid rain, increasing the nitrogen input of the park. In addition, in pursuit of the beauty of park vegetation and the rapid growth effect, park managers often over-fertilize. Unreasonable fertilization behavior leads to a sharp increase in nitrogen content in the soil, far exceeding the actual demand of plant growth. This excessive nitrogen input not only causes waste of resources but also has a negative impact on the park ecosystem.

Human activities also affect the nitrogen output process in urban parks. Although the artificial drainage system in the park has solved the drainage problem to some extent, it also accelerates the formation of surface runoff. During rainfall, a large amount of nitrogen is lost along with surface runoff and enters the urban water bodies, increasing the risk of water body eutrophication. At the same time, unreasonable land use methods, such as large-scale hard paving, reduce the contact area between the soil and water, and decrease the soil's ability to adsorb and fix nitrogen, further exacerbating nitrogen loss. Moreover, human activities can interfere with every link of nitrogen cycling in urban parks. Excessive irrigation changes the moisture and aeration conditions of the soil, affecting the normal operation of nitrification and denitrification processes. Nitrification requires suitable soil moisture and aeration conditions. Excessive irrigation leads to oxygen deficiency in the soil, inhibiting the activity of nitrifying bacteria, preventing ammonia from being converted into nitrate in time, and affecting the absorption of nitrogen by plants. Frequent pruning and trampling can damage the root systems and soil structure of vegetation, affecting the absorption and utilization of nitrogen by plants and the activity of soil microorganisms. When the root systems of vegetation are damaged, their ability to absorb nutrients decreases, while the destruction of soil structure affects the living environment of microorganisms, reducing their regulatory role in nitrogen cycling.

The causes of human disturbances mainly relate to the acceleration of urbanization, improper park management concepts and methods, and the lack of public ecological awareness. The acceleration of urbanization leads to a large increase in urban population, intensified industrial activities, and increased traffic flow, resulting in a continuous increase in atmospheric nitrogen deposition in urban parks. The excessive development and utilization of land during urban construction have damaged the natural ecosystem of urban parks and disrupted the original balance of nitrogen cycling. Some park managers lack ecological protection awareness and overly focus on the landscape effect of the park, neglecting the health and sustainable development of the ecosystem. In the process of park construction and management, some unreasonable measures have been adopted, such as excessive fertilization, frequent pruning, and large-scale hard paving, which have had a negative impact on nitrogen cycling. The public's insufficient understanding of the importance of urban park ecological protection and lack of environmental awareness and responsibility. Some tourists in the park randomly discard garbage, trample on lawns, and pick flowers, which not only damage the park's ecological environment but also indirectly affect the normal operation of nitrogen cycling.

## 4. Construction of an Assessment System for Human Disturbance in Urban Parks Based on Nitrogen Cycling

Constructing an assessment system for human disturbance in urban parks based on nitrogen cycling is a complex and systematic task that requires comprehensive consideration of various factors. The selection of assessment indicators is a key stage in the construction of the assessment system, and it should follow the principles of scientificity, representativeness, operability, and comprehensiveness.

The scientific principle requires that the assessment indicators can accurately reflect the characteristics of nitrogen cycling in urban parks and the degree of human disturbance, having clear scientific connotations and theoretical basis. Only with scientifically-based indicators can the assessment results be accurate and reliable.

The representativeness principle emphasizes that the selected assessment indicators should be representative, covering the main processes and key links of nitrogen cycling, as well as the main manifestations of human disturbance. Only in this way can the impact of human disturbance on the urban park ecosystem be comprehensively and objectively evaluated. The operability principle requires that the assessment indicators be easy to obtain and quantify, having operability and practicality. If the indicators are difficult to obtain or quantify, the assessment work will be difficult to carry out, and the assessment system will lose its practical significance.

The comprehensiveness principle requires that the assessment indicators should comprehensively consider various factors such as ecology, environment, and socioeconomics of nitrogen cycling, and comprehensively assess the impact of

human disturbance on the urban park ecosystem. Because human disturbance not only affects the ecological process of nitrogen cycling but also has a chain reaction on environmental quality and social economic development.

Based on the above principles, an assessment indicator system including nitrogen input indicators, nitrogen output indicators, nitrogen cycling process indicators, and ecosystem health indicators can be constructed. Nitrogen input indicators include atmospheric nitrogen deposition amount, artificial fertilization amount, etc., used to reflect the sources and intensity of nitrogen input in urban parks. By monitoring atmospheric nitrogen deposition amount and recording artificial fertilization amount, the changes in nitrogen input in the park can be understood. Nitrogen output indicators such as surface runoff nitrogen loss amount, groundwater nitrogen content, etc., are used to assess the output of nitrogen in the urban park and potential environmental risks. Monitoring the nitrogen content in surface runoff and groundwater can determine the degree of nitrogen loss and its impact on the surrounding environment. Nitrogen cycling process indicators cover soil nitrogen content, nitrification rate, denitrification rate, plant nitrogen absorption amount, etc., used to characterize the operation status and efficiency of each link of nitrogen cycling. These indicators can reflect the transformation of nitrogen between soil, plants, and microorganisms. Ecosystem health indicators include vegetation biomass, species diversity, soil microbial activity, etc., evaluating the impact of human disturbance on the ecological health of the urban park from the overall perspective of the ecosystem.

Vegetation biomass and species diversity reflect the structure and stability of the park ecosystem, while soil microbial activity reflects the ecological function of the soil. In the selection of assessment methods, the Analytic Hierarchy Process (AHP) can be used to determine the weights of each assessment indicator. The Analytic Hierarchy Process is a method that decomposes complex problems into multiple levels and compares the importance of elements between each level to determine the weights. Then, the Comprehensive Index Method is used to assess the degree of human disturbance in the urban park. The Comprehensive Index Method standardizes the measured values of each indicator and multiplies them by the corresponding weights, then sums them up to obtain the comprehensive assessment index. According to the size of the comprehensive assessment index, different disturbance levels can be divided, thereby intuitively reflecting the degree of human disturbance's impact on the nitrogen cycling in the urban park.

## 5. Regulatory Strategies Based on Evaluation Results

Based on the assessment results of human disturbances in the nitrogen cycle of urban parks, we can formulate a series of targeted regulatory strategies to reduce the negative impact of human disturbances on the ecosystem of the park and achieve sustainable development of the ecosystem. Source control strategies are the key to regulation. Reducing atmospheric nitrogen deposition is one of the important measures. Strengthening the governance of industrial pollution sources, promoting the use of clean energy, and reducing the emission of nitrogen oxides in industrial waste gas. Optimizing the urban traffic layout, developing public transportation, and encouraging green travel can reduce the emission of vehicle exhaust, thereby reducing the content of nitrogen pollutants in the atmosphere and reducing nitrogen deposition in urban parks. Reasonable fertilization is also an important part of source control.

Based on the soil fertility and plant growth requirements of urban parks, formulate a scientific fertilization plan. Avoid excessive fertilization and use environmentally friendly fertilizers such as organic fertilizers and slow-release fertilizers. Organic fertilizers can improve soil structure, increase soil fertility, and release nitrogen at a slower rate, which can meet the long-term growth needs of plants. Slow-release fertilizers can gradually release nutrients according to the growth stage and needs of plants, reducing nutrient loss and waste. Process control strategies are crucial for maintaining the normal operation of the nitrogen cycle.

Optimizing Park design and management is key. In the design of urban parks, plan land use methods reasonably, increase green space and wetland areas, and reduce hard paving. Green spaces and wetlands can increase the adsorption and fixation capacity of soil for nitrogen, reducing nitrogen loss. At the same time, adopt ecological drainage systems, such as grassy swales and rain gardens, to improve the infiltration and retention capacity of rainwater, reducing nitrogen loss from surface runoff. Strengthen Park vegetation management, avoid excessive pruning and trampling, and protect the root systems and soil structure of plants.

Based on the growth characteristics of plants and seasonal changes, determine the time and intensity of pruning to reduce interference with plant growth and the nitrogen cycle. Regulating soil moisture and aeration is also an important aspect of process control. Through reasonable irrigation and drainage measures, maintain appropriate soil humidity and aeration. In dry seasons, appropriately irrigate to meet the growth needs of plants, but avoid excessive irrigation that leads to oxygen deficiency in the soil. In rainy seasons, promptly drain water to prevent waterlogging that affects the respiration of plant roots and the processes of nitrification and denitrification. Terminal control strategies can be supplementary measures.

Constructing artificial wetlands is an effective terminal control method. In urban parks, build artificial wetlands to utilize their ecological functions for nitrogen purification. Plants in artificial wetlands can absorb nitrogen from water bodies, microorganisms can degrade organic matter and convert nitrogen, and the soil can adsorb and fix nitrogen. Through these processes, artificial wetlands can effectively remove nitrogen pollutants from water bodies, improve water quality, and reduce nitrogen pollution to the surrounding environment. Strengthening monitoring and management is an important guarantee for ensuring the effective implementation of regulatory strategies. Establish a sound nitrogen cycle monitoring system for urban parks, conduct regular monitoring of nitrogen content in soil, water bodies, and vegetation. Through long-term monitoring, promptly grasp the dynamic changes of the nitrogen cycle and the degree of influence of human disturbances. Based on the

monitoring results, adjust regulatory strategies to ensure the health and sustainable development of the ecosystem in urban parks.

Public participation and education strategies can enhance public environmental awareness and responsibility, creating a favorable atmosphere for the public to participate in the protection of urban park ecology. Strengthen publicity and education, through conducting environmental protection publicity activities, holding science popularization lectures, etc., to popularize important knowledge about urban park ecology and nitrogen cycle to the public, raising public awareness of environmental issues. Encourage public participation in the construction and management of urban parks, establish a public participation mechanism. Organize volunteer activities, allowing the public to participate in the planting and maintenance of park vegetation, garbage cleaning, etc., to enhance the public's awareness and action for the protection of park ecological environment.

## 6. Conclusion

The nitrogen cycle is a crucial component of the urban park ecosystem, and its normal operation plays an irreplaceable role in maintaining the ecological balance and ecological functions of the park. However, the disturbances caused by human activities to the nitrogen cycle in urban parks have seriously affected the health and service functions of the park ecosystem. By constructing an assessment system for human disturbances in urban parks based on the nitrogen cycle, we can accurately evaluate the degree and scope of human disturbances from multiple dimensions. This assessment system comprehensively considers multiple indicators such as nitrogen input, nitrogen output, nitrogen cycling process, and ecosystem health, providing a scientific basis for a comprehensive understanding of the impact of human disturbances on the nitrogen cycle in urban parks.

The control strategies formulated based on the assessment results, including source control, process control, end treatment, and public participation, are targeted and operational. Implementing these control strategies can effectively reduce the negative impact of human disturbances on the nitrogen cycle in urban parks, protect the ecological environment of urban parks, and promote the sustainable development of urban ecosystems. In the future, as the urbanization process continues and human activities become increasingly complex, the problems of urban park nitrogen cycle and human disturbances will face new challenges. Therefore, it is necessary to further strengthen relevant research and continuously improve the assessment system and control strategies. In-depth research on the changing patterns of the nitrogen cycle under different environmental conditions, exploration of more effective control technologies and methods, to adapt to the needs of urban development and ecological protection. At the same time, strengthening international cooperation and exchanges, drawing on advanced experiences and technologies from abroad, jointly promoting the development of urban park ecological protection, and contributing to the construction of a beautiful and livable urban environment.

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