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ORIGINAL RESEARCH ARTICLE

Analysis on the development trend and countermeasures of ecological city in Jinan

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ABSTRACT

By constructing the comprehensive evaluation index system of eco cities, this paper evaluates and analyzes the development trend of eco city in Jinan during the 12th Five Year Plan period. The results show that the comprehensive level of eco city in Jinan shows a steady development trend and is at the "healthy" level from 2011 to 2015. However, the change degree of various indicators affecting the development of eco city is different. Among them, the ecological economy shows a rapid development trend, the ecological society shows a slow development trend, and the ecological environment shows a shock change of decline in the early stage and recovery in the later stage, which has become the main factor affecting the promotion of eco city in the whole city. According to the evaluation results, this paper discusses the problems existing in the development of eco city and puts forward countermeasures and suggestions for weak links, in order to provide important reference for promoting the construction of local ecological civilization and system reform and improving the level of urban ecological development.

Keywords: ecological city; index system; development trend; Jinan city

1. Introduction

In 1971, UNESCO first put forward the concept of "ecological city" in the "comprehensive ecological research plan of human settlements" and attracted much attention[1]. Therefore, western scholars have carried out a lot of research[2,3]. China started relatively late. The "First National Symposium on urban ecology" held in Shanghai in 1984 marked the beginning of China's eco city research. Since then, relevant domestic research has sprung up[4,5]. Eco city is a complex system of environment, economy and society based on a certain geographical area, which reflects the common progress and coordinated development of ecological environment, economy and society. It is the trend of urban development[6]. In recent years, with the introduction of a series of policies such as the overall plan for the reform of ecological civilization system and the opinions on accelerating the construction of ecological civilization, the concept of ecological civilization has been highly valued by the state, which has promoted the acceptance and recognition of the ecological city theory by government decision-makers. All localities have put forward the strategic concept of building an ecological city[7], launched the practice of planning and construction, set off the up surge of ecological

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city construction again, and opened a new chapter for the study of ecological city.

Taking Jinan as the research object, this paper analyzes the development trend of eco city during the 12th Five Year Plan period, analyzes the existing problems of eco city construction, and puts forward countermeasures and suggestions to promote the development of eco city in the whole city according to the weak links, aiming to provide scientific reference for the construction of ecological civilization and standardizing the coordinated development of cities in Jinan, which is of great significance to enrich the theory and construction practice of eco city.

2. Overview of Jinan

As the capital city of Shandong Province, Jinan is the center of politics, economy, finance, logistics, culture, education and science and technology of the province. It is the main hub connecting the four economic zones of the Yangtze River Delta Economic Zone, Beijing Tianjin Hebei Economic Zone, Central Plains Economic Zone and Shandong Peninsula blue economic zone. It has an important strategic position in the middle and eastern regions of China[8].

In 2015, Jinan had an area of 8,117 km^2, a total population of 6.2573 million, a regional GDP of 610 billion yuan, ranking ninth among provincial capitals in China, and the tertiary industry accounting for 57.2% of GDP, ranking first in the province Jinan is known as the “Spring City”. The spring water in the spring city has been listed in the world natural and cultural heritage list. It is the largest resource endowment and core competitiveness of the city. In terms of ecological function orientation, Jinan is the main producing area of national agricultural products, and the landscape products and green fruits and vegetables industry have formed a scale. It is an important area for national soil conservation and a functional area for human settlement guarantee of key urban groups. The southern mountainous area within the jurisdiction provides the city with sustainable and stable ecological service functions and colorful ecotourism projects. In recent years, Jinan has vigorously promoted the “joint creation of six cities” and has been awarded the honorary titles of national forest city, national water ecological civilization city and national health city, indicating that the city has the environmental and economic foundation for the development of ecological city.

3. Construction of ecological city comprehensive development index system

3.1. Index system architecture

The index system of eco city is a set of measurable parameters to describe and analyze the development of eco city and an important basis for comprehensive evaluation and analysis of eco city development[9]. As for the selection of indicators, based on the principles of scientificity, systematicness, dynamics, representativeness and operability, on the basis of previous studies[10], and with reference to the indicators of national demonstration counties and cities for ecological civilization construction. In this paper, the evaluation system structure of eco city is divided into four levels: The first level is the general objective level of eco city. The second layer is the three system layers of environment, economy and society. The third layer is the function layer. The fourth layer is the index layer. Among them, there are 3 system level indicators, 11 function level indicators and 30 indicator level indicators. See **Table 1** for the evaluation index system of Jinan eco city.

3.2. Data sources

The data are mainly from 2012–2016 Jinan statistical yearbook and 2012–2016 Shandong Statistical Yearbook; for the setting of target value, refer to corresponding national standards, relevant planning requirements, current value of advanced ecological city or relevant literature[11].

Table 1. Comprehensive development index system of eco city

Total target layer	System layer	Functional layer	Index layer	Unit	Standard value
Comprehensive development of ecological cities	Ecological environment index (0.5)	Ecological level (0.2894)	Per capita urban green space area	m^2/person	13
			Greening coverage rate of built-up area	%	50
		Environmental quality (0.4515)	Sulfur dioxide	mg/m^3	60
			Nitrogen oxide	mg/m^3	40
			Fine particulate matter (PM10)	mg/m^3	70
			Water quality compliance rate of centralized drinking water source	%	100
			Average value of urban noise	dB	55
		Environmental governance (0.2591)	Centralized sewage treatment rate	%	100
			Disposal and utilization rate of industrial solid waste	%	100
			Industrial smoke (powder)dust removal rate	%	100
	Economic development index (0.25)	Economic level (0.2813)	Per capita GDP	yuan/person	138,000
			Per capita disposable income of urban residents	yuan/person	40,000
			Annual per capita disposable income of farmers	yuan/person	15,000
			Annual per capita general public budget income	yuan/person	10,000
		Economic benefit (0.3905)	Water consumption per unit of GDP	10,000 yuan/m^3	50
			Industrial added value per unit of industrial land	10,000 yuan/hm^2	1,275
			Energy consumption per 10,000 yuan GDP	t standard coal/(10,000 yuan)	0.5
		Economic structure (0.3282)	Proportion of financial industry in GDP	%	13
			Proportion of service industry in GDP	%	60
	Social development indicators (0.25)	Population index (0.2095)	Natural population growth rate	‰	7
			Population density	person/km^2	3,500
			Urbanization level	%	73
		Infrastructure (0.2465)	Per capita Road area	person/km^2	28
			Number of beds per 10,000 people	set/(10,000 people)	90
		Resource supply (0.2177)	Daily water consumption per capita	$L \cdot d^{-1}$	455
			Daily electricity consumption per capita	$kW \cdot h \cdot d^{-1}$	8
		Educational technology (0.2002)	10,000 students in higher education	%	50
			Proportion of science and technology expenditure in financial expenditure	%	3
		Social stability (0.1261)	The registered urban unemployment rate	%	1.2
			Incidence of criminal cases	case/(10,000 people)	40

Note: the weight of each index of system layer and function layer is in brackets

3.3. Calculation method

Using the method of weighted superposition, multiply the indexes at all levels by their respective weights, and then sum them again to obtain the value of the upper level index. The calculation formula is as follows:

$$U = \sum_{i=I}^{n} W_i \times V_i \tag{1}$$

Where: U is the index value of a certain type of index. W_i is the weight of the next level index. V_i is the index value of the next level index. i is the number of such next level indicators.

3.4. Weight determination

Determining the weight of each index is the basis of eco city evaluation. During the evaluation, the impact of specific indicators at each level is different. The index weight at the system level is determined by the assignment method based on the previous research experience[10]. The index weight of functional layer is determined by analytic hierarchy process, and the calculation method is as follows[11,12].

1) Normalize each column element of the judgment matrix:

$$\bar{b_{ij}} = b_{ij} / \sum_{k=1}^{n} b_{ij} (i = 1, 2, 3..., n) \tag{2}$$

2) Add the processed judgment matrix by row:

$$\overline{W} = \sum_{j=1}^{n} \bar{b_{ij}} (i = 1, 2, ..., n) \tag{3}$$

3) The vector is also normalized:

$$W_i = \overline{W} / \sum_{i=1}^{n} \overline{W_i} (i = 1, 2, ..., n) \tag{4}$$

4) The maximum eigenvalue of the judgment matrix is obtained:

$$\lambda_{\max} = \sum_{i=1}^{n} (AW)_i / nW_i \tag{5}$$

The consistency of indicators was checked: defining $CI = (\lambda_{max} - N)/(N - 1)$, N is the order of judgment matrix A, $\lambda = 11.05$, $CI = 0.005$. According to the table, $RI(11) = 1.52$, then, $CR = CI/RI = 0.003 < 0.1$, so the judgment matrix A has satisfactory consistency. See **Table 1** for the weight of each index.

4. Analysis on the development trend of eco city

4.1. Analysis of comprehensive development trend of ecological cities

During the 12th Five Year Plan period, the eco city development in Jinan showed a steady trend, as shown in **Figure 1.**

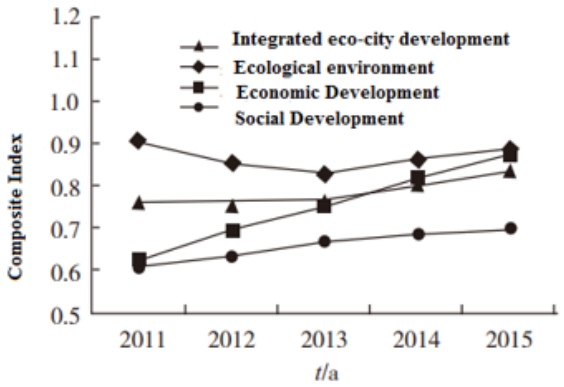

Figure 1. Changes in comprehensive eco-city development in Jinan from 2011 to 2015.

Environment, economy and society are three parts of the eco city comprehensive system. From the change trend of the three, the development of the three indicators is unbalanced. From the perspective of eco-environmental indicators, during the 12th Five Year Plan period, the eco-environment of Jinan showed a trend of slow recovery after decline, of which the eco-environmental index was the lowest in 2013. From the perspective of economic development indicators, the economic development of the whole city showed a straight-line upward trend during the study period. From the perspective of social development indicators, it shows a slow growth trend during the 12th Five Year Plan period.

4.2. Analysis on development trend of ecological environment

During the 12th Five Year Plan period, the ecological level has been optimized year by year, as shown in **Figure 2**.

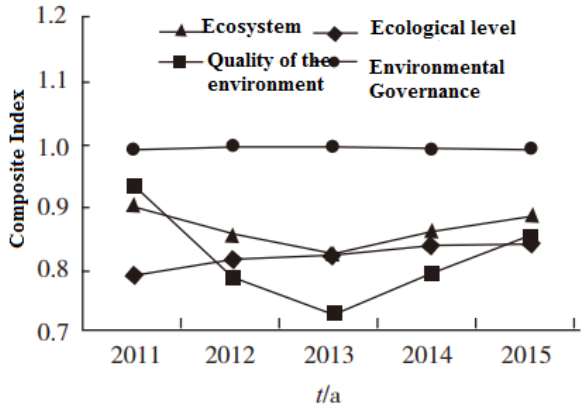

Figure 2. Development and change of ecological environment in Jinan from 2011 to 2015.

It can be seen from **Figure 2** that in recent years, Jinan has continuously strengthened the construction of ecological civilization and actively promoted the "joint creation of six cities", which has promoted the construction of gardens in the city. The green area has increased year by year and the ecological environment has been effectively maintained. The environmental quality first decreased and then increased. In 2013, the environmental quality of the whole city decreased to the lowest, and then increased year by year. The reason is that from 2011 to 2013, the concentration of sulfur dioxide, nitrogen dioxide and fine particulate matter (PM10) in Jinan increased continuously, and the haze pollution in the whole city was serious, resulting in the continuous decline of environmental quality. However, since 2013, the city has issued the action plan for the prevention and control of air pollution in Jinan, the work plan for the "ten actions" for the prevention and control of air pollution and other policies to strengthen the control of air pollution, promote the reduction of pollutant concentration year by year, and the environmental quality of the city has begun to improve. The change of environmental governance is weak and stable, which reflects the relatively stable pollution control ability of Jinan to a certain extent. Generally speaking, during the "12th Five Year Plan" period, the ecological environment of Jinan showed a development trend of decreasing first and then increasing. This trend is consistent with the change trend of environmental quality, which reflects that environmental quality is an important factor affecting the ecological environment, and the analysis shows that the key factor affecting environmental quality is air quality.

4.3. Analysis of economic development trend

From 2011 to 2015, the economic development of Jinan showed a linear upward trend, as shown in **Figure 3**.

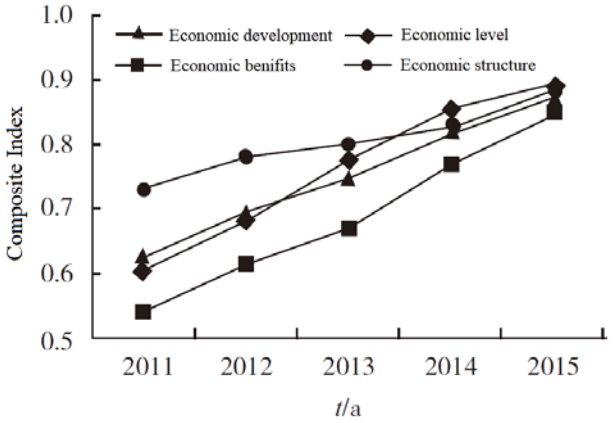

Figure 3. Economic development changes of Jinan from 2011 to 2015.

It can be seen from **Figure 3** that during the 12th Five Year Plan period, the city's economy showed a prosperous trend of rapid growth and vigorous developmentthe three functional indicators constituting the economic development subsystem show a rapid upward trend. The reason is that the proportion of per capita GDP, urban and rural per capita disposable income, general public budget, service industry and financial industry in GDP has increased year by year, indicating that the economic level has been rising and the economic structure has been optimized day by day. The water consumption per unit of regional GDP decreases year by year, the energy consumption per 10,000 yuan GDP decreases year by year, and the industrial added value per unit of industrial land continues to increase, indicating that with the development of economy, the level of resource conservation and cleaner production continues to increase, the performance of resource and energy utilization increases, and the ecological benefits brought by economic development are becoming increasingly prominent.

4.4. Analysis of social development trend

The social development of Jinan eco city and its impact indicators have different trends, as shown in **Figure 4**.

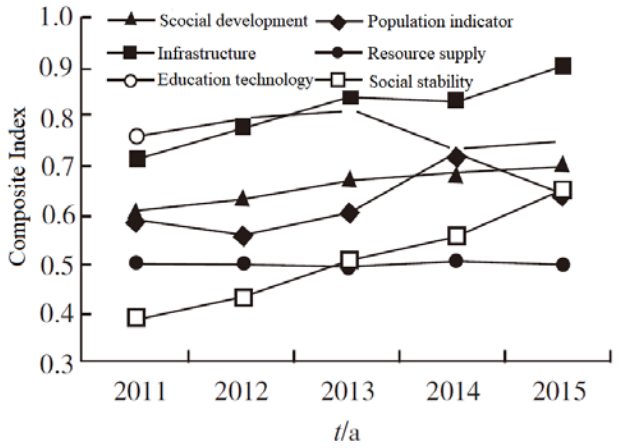

Figure 4. Changes in social development of Jinan from 2011 to 2015.

As can be seen from **Figure 4,** the population index shows a trend of decreasing first, then increasing and then decreasing. The fluctuating natural population growth rate is the main factor leading to the fluctuation of population index Infrastructure indicators showed an upward trend on the whole, but decreased slightly in 2014. The reason is that the number of 10,000 beds (74.1) in 2014 decreased by 5.8 per 10,000 compared with that in 2013 (68.3), which reduced the supply capacity of infrastructure. By 2015, the number of 10,000 beds rose to 788 per 10,000, alleviating the problem of insufficient infrastructure. The supply of resources is basically stable, because there is no significant change in per capita electricity and water consumption during the 12th Five Year Plan period. With the continuous increase of population, the city can still maintain a stable supply of hydropower, reflecting the city's strong capacity for sustainable supply of resources. Educational science and technology indicators have declined since 2013, because the proportion of science and technology expenditure in financial expenditure has decreased since 2013, which has affected the rapid development of science, technology and research to a certain extent. The social stability index is on the rise because the unemployment rate and the incidence of criminal cases are decreasing year by year. Generally speaking, the ecological and social level of Jinan has been steadily improved during the 12th Five Year Plan period.

4.5. Judgment of comprehensive level of ecological city in Jinan

Referring to the evaluation standard of eco city health index (ECHI) in the evaluation report of China's eco city health status[13], combined with the above index system and the actual situation of Jinan, the evaluation standard of eco city comprehensive development level is established, as shown in **Table 2.**

Table 2. Evaluation criteria for comprehensive development level of eco city

Type	Very healthy	Healthy	Sub-health	Unhealthy	Very unhealthy
Index range	≥0.85	<0.85, ≥0.7	<0.7, ≥0.6	≥0.45	<0.45

From 2011 to 2015, the comprehensive development index of ecological city in Jinan was 0.76, 0.76, 0.77, 0.80 and 0.84 respectively. According to the standard, the comprehensive development level of Jinan eco city during the 12th Five Year Plan period is in a "healthy" state. Although the development level of ecological environment, ecological economy and ecological society in Jinan is rising to varying degrees, and the comprehensive development level of ecological city continues to rise, it is still in a "healthy" state, and there is still a certain gap from the best "very healthy". The reason is that the ecological environment is the primary factor affecting the development of ecological city.

5. Countermeasures and suggestions for the comprehensive development of ecological city in Jinan

5.1. Optimizing the quality of ecological environment

As an important ecological protection area and green ecological barrier in Jinan, the southern mountainous area continues to provide ecological service functions such as water conservation, spring water supply, climate regulation and biodiversity protection, which is of great significance to maintain the ecological stability and ecological security of the whole city. Jinan should strictly implement the "South Control" strategy, limit industrial development, construction projects and urban expansion in southern mountainous areas, and protect ecological service functions. In the agricultural and forestry ecological area of the northern plain, we should strengthen forest tending and protection, highlight the ecological significance of forests, and organically combine windbreak forests, farmland forests and riparian forests to form a windblown sand shelterbelt system. At the same time, deepen the development of modern agriculture and green agriculture, reduce the use intensity of pesticides and chemical fertilizers, and reduce the emission of agricultural source pollution. In the built-up area of the city center, strengthen the greening construction between the main city and the east and west new towns, improve the ecosystem material and energy transmission function of the key green space corridors of the east and west new towns, and supplement the missing greening nodes. Pay attention to the protection and restoration of wetland ecological functions, restore the aquatic ecosystem of important rivers, strengthen the protection of springs, reservoirs and lakes, and ensure the supply of groundwater in springs. With the promulgation of the ecological protection red line plan of Shandong Province, Jinan should seize this opportunity to expand the scope of the municipal red line and strictly abide by the provincial and municipal ecological protection red line.

5.2. Strengthening environmental pollution prevention and control

The decline of atmospheric environmental quality is the main reason for the fluctuation of environmental quality in Jinan. Therefore, strengthening the prevention and control of atmospheric pollution is the top priority of environmental protection. We should actively adjust the energy structure, optimize the industrial layout, solve structural air pollution problems, strengthen the prevention and control of industrial enterprises, dust and motor vehicle exhaust pollution, prohibit high pollution projects from entering key control areas, deepen the joint prevention and control system of air pollution in provincial capital city clusters, and strive to achieve a fundamental improvement in air quality. At the same time, combined with the construction of sponge city, strengthen the regulation of urban black and smelly water bodies, and improve the city's sewage treatment and wastewater recycling capacity. Comprehensively carry out soil pollution prevention and control, find out the soil pollution status of the whole city, determine the priority areas for soil protection, control new pollution, and carry out soil treatment and remediation. In addition, strengthen the treatment capacity of industrial waste and medical waste, improve the supervision mechanism of hazardous waste, promote the classified collection and treatment of waste, and establish a recycling system of waste electronic appliances.

5.3. Promoting coordinated economic development

During the 12th Five Year Plan period, the proportion of the primary and secondary industries in Jinan decreased year by year, and the proportion of tertiary industry and high-tech industry continued to rise, as shown in **Figure 5.**

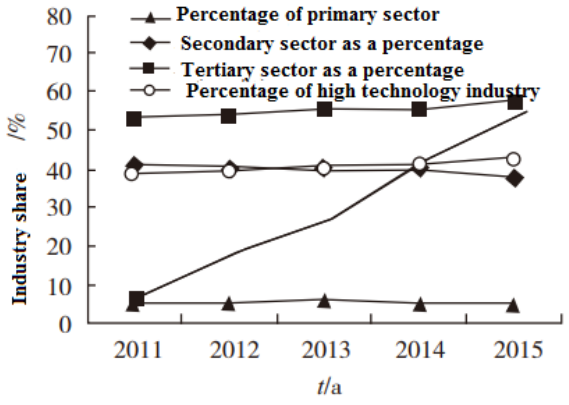

Figure 5. Proportion of tertiary industry and high-tech industry in Jinan.

In 2015, the proportion of tertiary industry in the city was 5.1:41.5:53.1, and the output value of high-tech industries accounted for 42.63% of the total output value of industries above designated size. Under the situation of supply side reform, we should adhere to innovation driven and green development, promote the effective resolution of excess capacity, and create a new path for the coordinated development of economy and environment. Based on this idea, vigorously develop information technology and Internet economy, promote the development and application of big data, and give play to the core driving role of high-tech industrial zones. Promote the innovative development of producer services and improve the level of R & D services, entrepreneurship incubation, transformation of scientific and technological achievements and intellectual property services. Promote the development of fine and intelligent new manufacturing industry, and cultivate emerging industries such as high-end equipment, biomedicine, new materials, energy conservation and environmental protection. Build an urban agricultural industrial system, build Zhangqiu, Licheng, Changqing, Pingyin, Jiyang and Shanghe agricultural science and technology demonstration parks, tap agricultural ecological value, leisure value and cultural value, and develop new business forms such as leisure sightseeing agriculture, experience agriculture and creative agriculture. At the same time, gradually establish the trading system of emission rights and carbon emission rights, improve the ecological compensation mechanism, organically combine economic development with environmental protection, and promote the harmonious and steady development of the two delimit water environment, air and soil pollution control areas, prohibit highly polluting industries from entering important pollution control areas, and implement environmental spatialization and fine management.

5.4. Promoting social harmony and progress

Strengthening social construction is a necessary part of eco city development. The grand goal of building a well-off society in an all-round way brings good opportunities for promoting the development of social undertakings. Starting from safe guarding the fundamental interests of the people and starting from the most concerned, direct and realistic interests of the people, the city should vigorously improve the level of basic public services, improve urban and rural public health and medical conditions, improve the urban transportation network, increase the per capita. Road area and alleviate the problem of traffic congestion. We will increase capital investment and policy support for education and scientific research, increase support for colleges and universities, scientific research institutes and new R & D institutions, promote major innovation platforms such as the National Super Computing Jinan Center and Shandong Institute of Quantum Technology, and enhance the ability of scientific and technological innovation. Give full play to the role of small, medium-sized and micro enterprises and private economy as the main channel for employment, improve the support policies of entrepreneurship to promote employment, and reduce the unemployment rate.

5.5. Establishing national participation system

Make full use of news, Internet, television and other media to strengthen the publicity and education of the concepts of ecological city, green development and circular economy, and improve the awareness of ecological protection in all sectors of society. Bring the construction and development of eco city into the education and training plan for government cadres, so that decision makers can firmly establish the concept of coordinated development of economy and environment, and consciously enhance their sense of responsibility and mission to maintain the harmonious development of eco city. Build a public participation mechanism, optimize and improve the information disclosure system of environmental quality and eco city construction, and promote social organizations, scientific research institutions and community residents to participate in decision-making and management.

6. Conclusions

With the introduction of ecological civilization system reform, supply side reform and other policies, China's eco city development has ushered in a new historical opportunity. However, at present, the transformation process of eco cities is different and most of them are in the primary stage, so it is still necessary to further strengthen the construction of eco cities with coordinated environment, economy and society. Through the construction of Jinan eco city evaluation system, this paper analyzes the development trend of eco city during the 12th Five Year Plan period, and evaluates the comprehensive development level of eco city. The results show that the comprehensive level of eco city in Jinan presents a steady development trend and is in a "healthy" state, while the development degree of the three indicators constituting the development of eco city is uneven, the ecological economy shows a rapid development trend, and the ecological society shows a slow development trend. The ecological environment condition has a shock change of decline in the early stage and recovery in the later stage. The fluctuation of air quality is the fundamental reason for the change of ecological environment. At the same time, relevant countermeasures and suggestions are put forward for weak links, in order to provide scientific basis and important reference for the development of ecological city and the construction of ecological civilization in Jinan.

Conflict of interest

The authors declare no conflict of interest.

References

1. Jiang Y, Liu C, Zhou C, et al. Theoretical research status and practical problems of ecological city in China. Geographical Research 2015; 34(12): 2222–2237.
2. Mi K, Peng Y. Analysis of eco city index system and its application abroad. China Population Resources and Environment 2014; (S3): 129–134.
3. Li H, Yu L. Study on the construction of ecological city evaluation index system in China. Urban Development Research 2011; 18(7): 81–86.
4. Li J, Sun P, Xu J. Review on the con striction of urban ecological civilization in China. Economic Geography 2014; 34(8): 137–142.
5. Wang N, Yin Q. Research on ecological city con striction of Zhengzhou based on ecological footprint model. Environmental Protection Science 2014; 40(2): 67–71.
6. Liu Z, Ma J. Summary of research on theory and practice of eco city construction. Environmental Science and Management 2013; 38(2): 159–164.
7. Zhang W, Zhang H, Wang L, et al. A new method for constructing the evaluation index system of eco city construction—Combined dynamic evaluation method. Journal of Ecology 2014; 34(16): 4766–4774.
8. Liu K. Evaluation of urban livability from the perspective of ecological civilization—A case study of Jinan city, Shandong province. Resource Development and Market 2015; 31(6): 653–656.
9. Yu H, Jia Y. Discussion on countermeasures of ecological city construction in Shenyang. Journal of Environmental Science 2011; 30(1): 20–22.
10. Peng J. Research on the construction of ecological city in Jinan. Jinan: Shandong Normal University; 2009.
11. Zheng C. Study on index system and counter measures of ecological city construction in Fuzhou. Journal of Environmental Science 2013; 32(5): 35–38.
12. Li F, Wang Z, Qi X. Construction and evaluation results of ecological city index system in Jiamusi. Environmental Science and Management 2012; 37(7): 150–152.
13. Zhao T, Liu H, Xie J, et al. Evaluation report on the health status of ecological cities in China. Beijing: Social Science Literature Press; 2015. p. 65.