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Economic Development Mode and Countermeasure Research on the Nansi Lake Drainage Area Based on Circular Economy

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Abstract Firstly, it is pointed out that circular economy should be vigorously developed in the Nansi Lake Drainage Area, and the connotation of circular economy is expounded. Then, problems in developing circular economy in Nansi Lake Drainage Area are analyzed from the aspects of agriculture, industrial enterprises, and waste utilization. Finally, combining with the four modes of peasant household, enterprise, region and society in the development of circular economy, corresponding countermeasures are put forward for the circular economy in Nansi Lake Drainage Area, such as establishing the government guidance mechanism for big agriculture circular economy in Nansi Lake Drainage Area, constructing incentive systems for industrial enterprises adopting circular economy in Nansi Lake Drainage Area, adjusting the industrial structure of Nansi Lake Drainage Area, and optimizing the energy consumption structure.

Key words Circular economy, Nansi Lake Drainage Area, Development model, Countermeasures, China

Nansi Lake Drainage Area, including the four areas of Jijing City, Heze City, Zaozhuang City and Ningyang County, is the ecological source and green barrier for the South-to-North water diversion. The water resource environment of Nansi Lake Drainage Area has close linkage to the success of the east route of South-to-North water diversion, as well as to the security of social and economic construction in Nansi Lake Drainage Area. With the implementation of the east route of South-to-North water diversion, non-point pollution becomes more serious, although the point pollution becomes under control gradually. Especially, the pollution on big agriculture has damaged the safety of water quality in Nansi Lake, which becomes a threat to maintain the surface water quality in water transferring line at the National Grade III in east route of South-to-North water diversion. Therefore, it is very important to vigorously develop the circular economy in Nansi Lake Drainage Area, so that the high-quality water can be transferred into north China and the social and economic development in Nansi Lake Drainage Area can take the road of efficient recycling economy.

1 Connotation of circular economy

Circular economy is a closing-cycle economic pattern formed in the late 20th century, which aims to realize the sustainable development, to protect the ecological environment, and to maintain the ecological balance. It is a new economic development model promoting the harmonious development between human and nature^[1]. Circular economy is essentially a

kind of ecological economy, which uses ecological laws to guide the economic activity of human society.

Circular economy turns the originally isolated wastes discharged in different production processes into renewable resources or recycled products by using technical process measures. It implements the innovative production method of sustainable development strategy, which is an economic development model with reversible cycle, multi-directional cycle and multi-level utilization through the circulation, transformation and appreciation of materials. This circular model has replaced the traditional economic model, which has the characteristics of high exploration and low utilization, high emission and high damage, high consumption and high pollution. Taking the efficient utilization and cyclic utilization of resources as the core, circular economy, a new economic development model, follows the principle of "Reducing, Reusing, Recycling", and has the basic features of low consumption, low emission and high efficiency^[2].

2 Problems existing in the development of circular economy in Nansi Lake Drainage Area

2.1 Serious pollution of big agriculture In the year 2007, the total fertilizer applied in planting industry is 36 801.3 tons per year in Nansi Lake Drainage Area, and the average amount of fertilizer applied reaches 54.40 kilograms per hectare, which are mainly the nitrogenous fertilizer, phosphorus pentoxide, and potassium oxide. Jining City and Heze City have applied relatively great amount of fertilizers, which are 16 810.6 and 10 221.6 tons, respectively (Fig. 1). In the year 2007, the sewage quantity of livestock and poultry is 3 185.8 tons in Nansi Lake Drainage Area, and its discharge amount reaches

Received: February 2, 2011 Accepted: February 15, 2011

Supported by the National Water Pollution Control and Management Technology Major Projects(2009ZX07210-007).

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1 707.3 tons. Among the four areas, Jining City has the maximum wastewater output and emission, accounting for 87.93% of the total wastewater emission (Fig. 2). In the year 2007, annual amount of pollutants generated by aquaculture industry is 220 million cubic meters. Pollutants directly discharged into water body are 110 million cubic meters, accounting for 52.5%. Thus, it has relatively great direct influence on the surrounding water body.

2.2 Heavy task of pollution control for industrial enterprises According to statistics, there are 11 500 pollution sources of the whole drainage area in the year 2007, 5 422 of which are major pollution sources, accounting for 47.15%. Among these

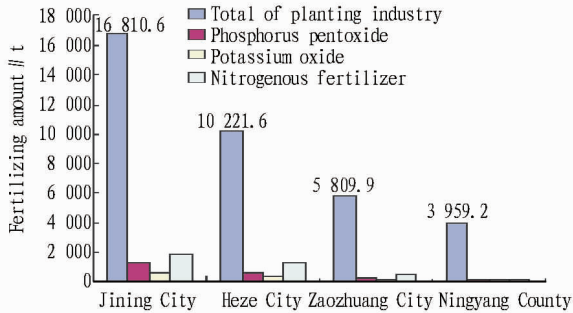


Fig. 1 Fertilizing amount of planting industry in Nansi Lake Drainage Area

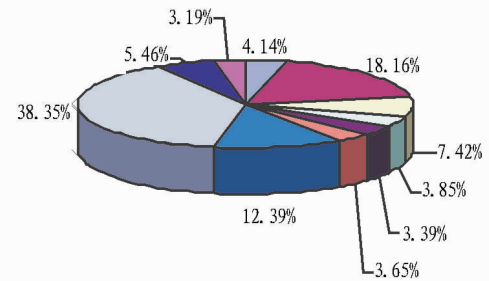


Fig. 3 Distribution of the pollution sources of different industries in Nansi Lake Drainage Area

High emission industries are widely distributed in Nansi Lake Drainage Area. Enterprises with discharge of industrial wastes are relatively high concentrated. The top 6 industries with high proportions of COD emissions are the papermaking and paper products industry, the chemical raw material and chemical manufacturing industry, the food manufacturing industry, the processing industry of agricultural and sideline products, the pharmaceutical industry, and the coal mining and washing industry, which in all account for 74.76% of the emissions (Fig. 4). Industries with high proportions of NH₃-N emissions in the Nansi Lake Drainage Area are the chemical raw material and chemical manufacturing industry, the food manufacturing industry, the oil processing, coking, and atomic fuel processing industry, the processing industry of agricultural and sideline products, the pharmaceutical industry, and the beverage manufacturing industry, which in all account for 98.21% of the emissions (Fig. 5).

2.3 Low utilization ratio of wastes At present, wastes recycling utilization is just at its initial stage in the agricultural de-

velopment of Nansi Lake Drainage Area. Thus, utilization ratio of wastes is relatively low. According to the statistics, annual output of straw in Nansi Lake Drainage Area is 89.3 thousand tons in the year 2007, most of which are directly returned to the field. Therefore, the utilization ratio is relatively low. Moreover, annual aquaculture pollutions of Nansi Lake reach 256 million cubic meters, and the recycling pollutions are 45 million cubic meters, accounting for 17.49%. Wastewater quantity caused by livestock and poultry is 31 858 thousand tons per year, and the recycling quantity is 14 785 thousand tons per year, accounting for 46.4%.

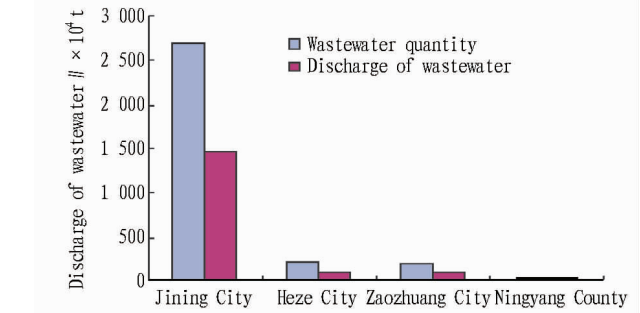
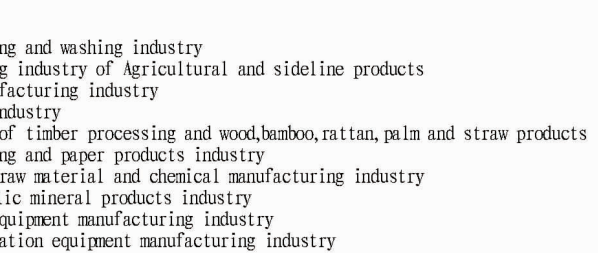


Fig. 2 Wastewater quantity of livestock and poultry raising in Nansi Lake Drainage Area



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The efficiency of resource utilizing of industrial development needs further improvement. Industrial water reusing in Nansi Lake Drainage Area is about 3908 million tons, with a re-using rate of 86.78%. Among the industries with relatively great water reusing rates, the oil processing, coking, and atomic fuel processing industry, the chemical raw material and chemical manufacturing industry, the pharmaceutical industry, and the electricity and heating production and supply industry

have relatively high proportion of water reusing; while the textile industry has the lowest reusing rate. Besides, reusing rates are low in the coal mining and washing industry, and the mining

and washing industry for ferrous metal ores, which are both lower than 50% .

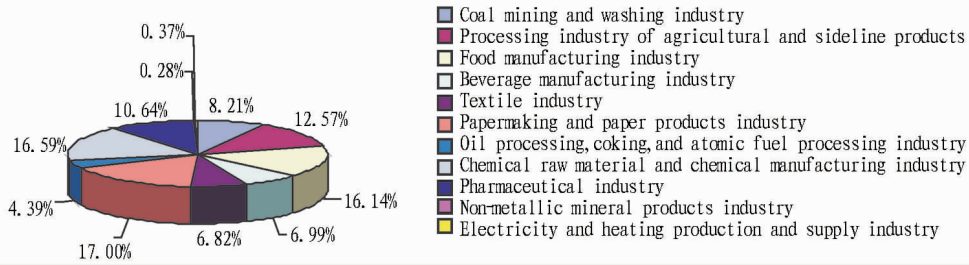


Fig.4 Proportions of COD emissions of different industries in Nansi Lake Drainage Area

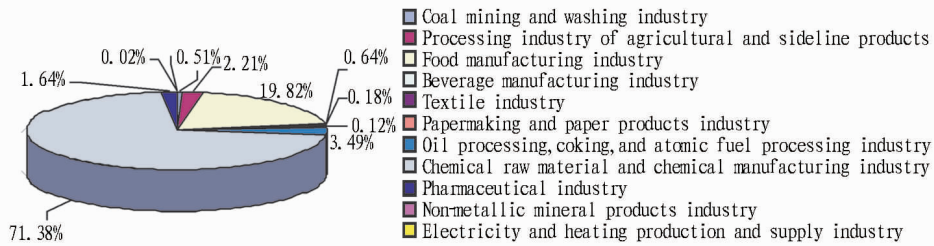


Fig.5 Proportions of NH₃-N emissions of different industries in Nansi Lake Drainage Area

3 Development modes of circular economy in Nansi Lake Drainage Area

According to the characteristics of Nansi Lake Drainage Area, the lakeside belt is the key to protect water quality. Economic development modes of peasant households in the lakeside belt directly affect the water safety in Nansi Lake Drainage Area. Therefore, circular economy should be implemented in Nansi Lake Drainage Area from four layers of peasant household, enterprise, region and society. 3R principle is used to realize the closed loop flow of material and to form an integrated economic system^[3], which is shown in Fig. 1. Peasant households in the lakeside belt are the main body of circular economy mode established. The micro-cycle of material and energy within enterprise is taken as the main body in enterprise mode, so as to establish a micro-cycle economic system with clean production and water pollution control. Region is the combination of enterprises, which realizes the recycling of resources within the whole society through production, consumption and circulation. It is the material flow and energy flow among enterprises (industries) by simulating the circulating approach of "Producer - Consumer - Decomposer" in natural ecosystems, mainly including the ecological park and ecological city construction. In the layer of region, ecological agriculture, ecological industry and ecological service industry systems are established. The layer of society is the most advanced mode of ecological economy, which combines the industry and agriculture, the production and consumption, and different industries by ecological chains, in order to gradually establish a recycling-based society.

3.1 Peasant household mode in the operation of circular economy Peasant households in Nansi Lake Drainage Area mainly breed ducks and chicken and plant shallow water lotus and so on. At the micro level, a peasant household is taken as a unit of the clean production and cycling, so that all the re-

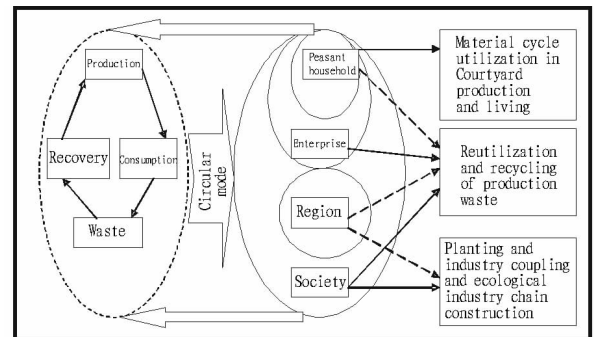


Fig.6 Development modes of circular economy in Nansi Lake Drainage Area

sources and energies can be effectively utilized. For instance, poultry manure can be used as the biogas fuel; waste products of biogas can be put into the fields planting shallow water lotus, so that the pollution-free emission or zero-pollution emission can be achieved. In the agricultural industrial chain, according to the economic development characteristics of Nansi Lake Drainage Area, and the wide range of agricultural non-point source pollution in lakeside belt, high-efficient ecological agriculture industry chain is established with biogas as a link, based on the principles of "operability, and easy things first". For instance, ecological industrial chain of agricultural planting industry, ecological industrial chain of vegetable industry, ecological industrial chain of animal husbandry, and fruit forest industry chain can be established to reduce agricultural pollution and to improve the re-use of resources.

3.2 Enterprise mode in the operation of circular economy

After the appropriate treatment of material recovery with enterprise as the unit to realize clean production and to organize the internal material circulation within enterprises, materials re-

turn back to the original process or other processes in the enterprise, so as to achieve clean production, reduce the usage quantity of materials and energy, and to lower the emissions of toxic substances and the pollution of enterprise wastes. There are two directions of enterprise circular mode. One is enterprise internal circular (internal circular), and the other is enterprise external circular (external circular). Under the internal circular, enterprises recycle, treat and reuse the wastes by their own; under the external circular, enterprises transfer the wastes into other places; other enterprises recycle, treat and reuse the wastes, which aim to protect the environment, save resources, and achieve the reuse of wastes. Enterprises or factories are combined together through the transfer modes of energy flow and material flow, forming a combination of industrial symbiosis. Thus, the wastes or by-products of one factory become the raw materials or energy of other factory or enterprise. Based on simulating natural systems by computer, the circulating approach of "Producer – Consumer – Decomposer" in industrial system is established in order to seek for closed loop material, multi-level energy utilization, and waste production minimization, as well as to realize the coordinated development among economic, social and environmental benefits of parks.

Clean production of enterprises is a basic form of enterprise to realize circular economy. According to the conception of clean production and the successful practices around the world, approaches to implement clean production include improving the design of products, replacing the toxic and hazardous raw materials, strengthening the process control during production, optimizing operating parameters, enhancing equipment maintenance, and increasing waste recycling and reuse.

3.3 Region mode in the operation of circular economy

According to the principles in ecology, the "metabolism" and "symbiosis" among enterprises and the "industrial ecological chain" of circular system are regarded as embodiments of circular economy at medium view level. Both of the clean production of an individual enterprise and the circulation within an enterprise have certain limitation, which are either restricted by the technical process, or by the high cost. Therefore, Ecological Industrial Park should be established to realize the circulation of material flow and energy flow among enterprises, and to reduce the emission of industrial wastes and by-products to the minimum level. The industrial ecological system advocated by circular economy requires a symbiotic and dependant relationship among enterprises. In other words, according to the theory of ecological economy, an interdependent and symbiotic relationship with closely linkage among enterprises within the region is formed based on the energy, material and information sharing and reuse, so that a high-efficient ecological industrial park is established. Nansi Lake Drainage Area vigorously develops high-efficient ecological industrial park, regards the planting industry, breeding industry and forest industry as one regional system, rationally distributes the material flow and information flow in industrial park, effectively simulates the natural ecosystem, and finally forms a symbiotic network among enterprises within the region.

As is well known, the first and most famous ecological industrial park is the Kronborg Industrial Park in Denmark, which has power plant, oil plant, pharmaceutical factory, gypsum plate factory, and calcium sulphate factory. Power plant utilizes the steam and heat, supplies energy to the oil plant and pharmaceutical factory nearby, provides residences with heat, and sends the rest heats to the fish factory and greenhouse planting and so on. Besides, the wastes and by-products produced by enterprises are exchanged within the industrial park, which can reduce the emission of wastes and save the costs for the disposal of garbage and pollutants, lower the production costs of enterprises, and produce economic benefits. Thus, a virtuous circle with regional economic development, environmental protection, and resources saving is formed; and the "industrial symbiotic system within the park" is spontaneously created. During the 10th Five-Year Plan Period, China has established a large number of high-tech ecological industrial zones with high quality, high efficiency and low emission, such as Dalian Development Zone, Tianjin Development Zone, and Suzhou Development Zone. Among them, Guangxi Guigang and Guangdong Nanhai Ecological Industrial Parks are the most well-known^[4].

3.4 Society mode in the operation of circular economy

Large-scale circulation system at society layer is established based on the small-scale circular economy of peasant household and enterprise and the medium-scale circular economy of region, which is the reflection of circular economy in the whole society at macro-level. It aims to establish an environment-friendly and resource-saving society, and tries to realize the minimum consumption of resources and energy during economic development. Within the range of ecological carrying capacity, "circular economy mode" with coordinated development of social and economic resources can be realized.

The whole society should establish the concept of circular economy, and set up public ethics of green production, moderate consumption, environment friendly, and sustainable use of resources. At the same time, Nansi Lake Drainage Area should advocates circular economy through media and newspapers, actively promote green consumption, and establish a sense of circular economy at society layer. During the production, clean production techniques with low energy consumption and less emission should be adopted. In the daily life, products with high pollution should be less used and green products with environmental protection and energy saving should be implemented.

4 Countermeasures for the development of circular economy in Nansi Lake Drainage Area

4.1 Establishing the government guidance mechanism for big agriculture circular economy in Nansi Lake Drainage Area

Nansi Lake is an important regulating reservoir for the east route engineering project of South-to-North water diversion. Thus, it is very important to implement circular economy in the Nansi Lake Drainage Area. At present, large-scale enterprises in Nansi Lake Drainage Area have relatively weak environmental awareness, as well as the small-scale enterpri-

ses in lakeside belt. According to the investigation, villages around the lakeside directly throw domestic garbage into Nansi Lake, which seriously affects the water quality of lake. Moreover, some peasant households breeding poultry directly put untreated manure into the lake, which contaminates the lake and deteriorates the surrounding environment. Therefore, the most fundamental way to solve the environmental pollution in lakeside belt is to establish a relatively perfect government guidance mechanism. Government should introduce biogas project in Nansi Lake Drainage Area, guide the farmers in lakeside belt to set up methane tank. For instance, the circular agricultural mode of "Biogas – Fish – Duck – Grass" should be implemented among the farmers breeding ducks in lakeside belt. Taking the Nanyang Village which is about 1 kilogram from the Nansi Lake as an example, the village has in all 740 peasant households, 3 100 population, and 173.33 hectares cultivated land, which is a production base of lotus root in Shandong Province. There are 66.67 hectares paddy fields and the per capita cultivated land is 0.017 hectare. Villagers mainly live on planting lotus root, breeding fish and duck. A total of 12 peasant households raise ducks with in all 40 cotes. Adopting the duck-fish polyculture mode, annual income of each peasant household is about 80 thousand to 10 thousand RMB if they breeds 3 thousand to 4 thousand ducks. According to the investigation, these farmers are willing to establish methane tank, because it can reduce the cost of living, and the pollution on the surrounding environment. Therefore, government should offer both technical and financial supports for them.

4.2 Constructing incentive systems for industrial enterprises adopting circular economy in Nansi Lake Drainage Area

Government should set up resource recovery system, collocate waste treatment facilities, provide financial subsidies and preferential loans for the enterprises with recycling use of resources, increase punishment for enterprises with high consumption, high emission, and high pollution, so as to force them to take the road of low consumption, low pollution and recycling use of resources^[5]. Incentive system of circular economy aims to organically combine the environmental benefits and the benefit maximization together, so as to promote the development of circular economy^[6]. Government should establish an accounting system for green economy, implement green economy appraisal system for cadres, establish the concept of scientific development among cadres at all levels, take the development road of circular economy, green economy, and low carbon economy, protect the ecological environment of Nansi Lake Drainage Area, and ensure the construction of east route engineering project of South-to-North water diversion.

4.3 Adjusting the industrial structure of Nansi Lake Drainage Area; optimizing the energy consumption structure

In the year 2007, Nansi Lake Drainage Area obtains a GDP of 334 759 million RMB, up by 21.5%. The economic aggregate shows a rapid growth trend. Proportions of three industries has changed from 18.6:48.4:33.0 in the year 2003 to 14.2:56.3:29.5 in the year 2007. The "secondary, tertiary, primary" industrial pat-

tern is further optimized. Economic and social development in Nansi Lake Drainage Area shows an over-reliance on secondary industry; while development of industry is an important pollution source, which seriously contaminates water environment. High emission industries are the major industry in Nansi Lake Drainage Area, which are mainly the coal mining, paper making, food processing, chemical engineering enterprises and other 11 industries. Enterprises belonging to these 11 industries account for 86.6% of the total number of enterprises in this area, but discharge as high as 92.13% COD and 99.03% NH₃-N. These industries have high energy consumption, heavy pollution, and low resource utilization ratio. Therefore, on the one hand, according to the national policy and the policies about industrial development made by Shandong Province, Nansi Lake Drainage Area should cultivate new investment growth points as soon as possible based on the market demand, such as vigorously developing high-efficient ecological agriculture, industrial park, and leisure tourism. On the other hand, Nansi Lake Drainage Area should introduce high-tech industry to replace the traditional industry with high pollution, high consumption and high emission. According to the principle of "overall planning, step-by-step implementation, demonstrative role, overall promotion", the development idea suitable for the Nansi Lake Drainage Area is put forward, which gathers points, lines and planes and integrates small-, medium-, and large-scale circulation. In the chemical, coal and medicine industries, Nansi Lake Drainage Area should promote clean production, and promote the circular economy mode for waste recycling.

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