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Effective Stockbreeding Biomass Resource Use and Its Impact on Water Environment from the Viewpoint of Sustainable Development

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The stockbreeding industry plays a vital role in the food production system, and it is expanding rapidly in the rural areas around large Chinese cities such as Beijing. On one hand, with rapid development of living standard, the demand for animal products dramatically increased; on the other hand, this industry carries a high environmental risk in terms of COD (Chemical Oxygen Demand) and T-N (Total Nitrogen) and T-P (Total Phosphorous) levels because of large amounts of pollutants released to rivers. However, as a typical biomass resource, stockbreeding waste can be used as an energy source in advanced technologies. We raised integrated basin management policy from the aspects of economy, society and water environment and we performed a computer simulation of this integrated basin management policy in Miyun County, Beijing. We modeled the integrated basin management policy with introduction of two new technologies to enhance the stockbreeding production and improve the environment from the sustainable development viewpoints. The model considered both the water environmental system in the region and the socioeconomic situational changes over a 10-year period. This paper briefly reviews our researches about biomass resource use and water environmental protection. The purpose of our research was to establish a method for effectively enhancing food security, with coordination between water environmental protection and economic development in order to contribute to sustainable development.

Key words: water environmental protection, basin management policy, sustainable development

1. Introduction

Improperly treated on stockbreeding wastes is due to water pollution discharged from socio-economic activities of the local people, but there is no reason to think that we should deteriorate local socio-economic activity level and decrease industry production to improve water environmental quality. Therefore, we should find a way from the viewpoint of sustainable development to reduce water pollution without deteriorating the socio-economic activity level and production of stockbreeding industry.

Miyun County is the largest semi-rural area and most important county as a key supplier of animal products of Beijing. The production of stockbreeding industry as a pillar industry accounted about 59% of the first industry production in this area (Miyun County Statistics, 2007). Miyun Reservoir, Beijing's only surface water resource, provides more than 60% of the water resources for Beijing (Miyun County Statistics, 2007). This important ecological value of Miyun County has unique significance for the region's environment and dra-

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matically influences water quality and local development in Beijing. However, majority of stockbreeding wastes generated in the catchment of the Miyun Reservoir have been improperly treated and contribute heavily to water pollution, and pig farming has become the source of the most serious pollution in the Miyun Reservoir. On the other hand, stockbreeding waste is a carbon-neutral biomass resource that can be used to produce biomass energy through advanced technologies. Therefore, in formulating integrated basin management policies to increase stockbreeding industry production, enhance food security and reduce the quantities of water pollutants emitted by the stockbreeding industry, we need to consider the comprehensive use of livestock feces and urine as biomass resources.

Recently, many studies have explored how to protect the regional environment and improve economic development. Hirose and Higano (2000) proposed integrated policies for different source pollution to reduce the emission of water pollutants and performed simulation analyses to evaluate water purification policies in the catchment area of Lake Kasumigaura, Japan. Mizunoya *et al.* (2006) analyzed and assessed synthetic environmental policies to reduce environmental burdens through the application of biomass technology and approved that the introduction of biomass recycle plant is effective to reduce the environmental pollution emitted by pig farming industry. China's state environmental protection administration has estimated the quantities of pollutants in stockbreeding wastes and the benefits of methane fermentation. However, there has been little research into the construction and analysis of a comprehensive simulation policy that is tailored to suit China's economy and social state and includes the introduction of different technologies to control water pollutant emissions and increase stockbreeding industry production, especially in the semi-rural areas around large cities.

This paper briefly reviews our researches, we used computer simulation to analyze synthetic environmental management policies (integrated basin management policy), including the introduction of two technologies, to improve the environment and increase stockbreeding industry production. We considered both the ecological system in the study area and socioeconomic situational changes over a specified period. To achieve our research purposes to minimize total nitrogen (T-N) levels over 10 years, a water pollutant flow-balance model and a socioeconomic model were specified to express all the key factors and parameters reflecting the environmental situation and affecting human activities. We then used the computer simulation models to analyze the synthetic basin management policy with the introduction of two new technologies in the study area.

2. Simulation Model

2.1 Classification of Water Pollutant Sources and Sub-Basins of Main Rivers

The Chao and Bai rivers are the main rivers flowing into the Miyun Reservoir. The two rivers flow through nine towns of Miyun County. These rivers are structured into the model, and other small rivers in the sub-basins flow into these two rivers.

We measured three indicators of water pollution —T-N (total nitrogen), T-P (total phosphorus), and COD (chemical oxygen demand). Household wastewater disposal systems were classified into one of two categories (sewage plant and untreated waste water) based on the setup in the semi-rural areas; land use was classified into five categories of non-point source pollution (Upland cropping, Forest land, Orchard land, City area and Other land area); and industry was classified into seven categories of production-based pollution based on the characteristics of Miyun County (Fisheries, Pig farming, Other stockbreeding industries, Forestry, Planting industry, Manufacturing industry and Other industries).

2.2 Integrated Basin Management Policy

We present the integrated basin management policy for different source pollution. We provide subsidization of different industries to reduce working capital and thus adjust production. This policy used in the simulation model to reduce water pollution and the government-selected the policy used to efficiently improve the regional water environment. According to the results of previous research, the pig farming industry has become the source of the most serious pollution in the Miyun Reservoir. In the water of the reservoir, more than 25% of T-N,

41% of T-P, and 36% of COD result from the pig farming industry. The local government has introduced wet methane fermentation technology to treat serious water pollutants emitted by the stockbreeding industry (particularly pig farming) (Miyun County Statistics, 2007). However, the efficiency of wet methane fermentation technology is not sufficient to treat the high concentrations of wastes in the water and meet the requirements of future economic development in the catchment area (unpublished data). Therefore, we introduced integrated basin management policy with two technologies, a new energy project and a biomass recycling plant for targeted treatment of the serious pollutants emitted by the pig farming industry. The government also proposed and provided preferential prices for farmers to promote the use of organic fertilizer.

2.3 Framework of the Model

The integrated basin management policy was derived to minimize T-N, which was subjected to analysis by the submodels of water pollutant flow-balance model and socioeconomic model. The water pollutant flow-balance model described how water pollutants flowed into the rivers and reservoir. The socioeconomic model represented social and economic activities in the region and the relationship between these activities and emission of pollutants.

The biomass recycling plant was developed by Ibaraki Prefecture, Japan, as a city area project to promote coordination between industry, academia, and government and to promote the advancement of regional science and technology in the Lake Kasumigaura Biomass Recycling Development (Mizunoya *et al.*, 2006). New Energy Project was developed by the city of Hangzhou, China, to promote effective and comprehensive utilization of pig wastes. The project was classified as a state-level pilot project (unpublished data).

Protection and development of the water environment in the upstream parts of Miyun Reservoir are of the greatest priority because this reservoir is the only surface water resource for Beijing. In addition, various trial calculations revealed that T-N was the pollutant that was the most difficult to degrade. Therefore, we constructed an objective function to minimize the total net load of water-polluting T-N over the target term (ten years) in order to determine the optimum integrated basin management policy.

3. Simulation Results

The variations in objective function value are shown in Figure 1. We defined the simulation results that reflected the level of economic development (gross regional product, GRP) as increases of n% in 2016 compared with 2007. After the introduction of integrated basin management policies, the net load of total nitrogen decreased about 8.5% and regional economy (GRP) increased 10% when we introduced integrated basin management policies as compared to when the policies were not

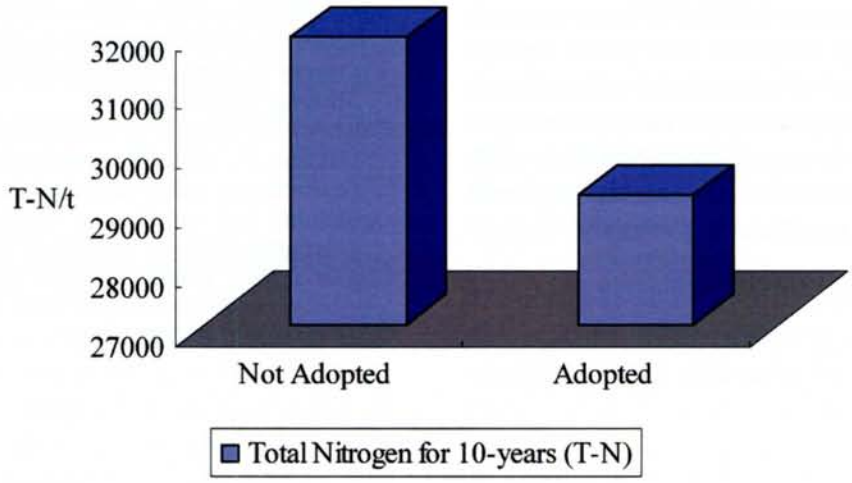

Fig. 1. Objective values of T-N (sum of T-N values over 10 years).

adopted.

For the simulation we adopted an integrated basin management policy that introduced two new technologies; in this simulation the policy was very effective in reducing the levels of water pollution indicators. Comparison of the results of the simulation revealed that the introduction of integrated basin management policies with new technologies was effective in reducing water pollution and at the same time enabling economic development. When the new technologies were introduced and GRP increased by 20% from 2007 to 2016, the total net load of T-N (sum of T-N for 10 years) reduced 2689 t less than when the integrated basin management policies with technologies were not adopted (unpublished data).

The net load of T-N is reduced by 25.3%, the net load of T-P is reduced by 42.0%, and the COD is reduced by 36.7% in 2016 as compared to the initial year (2007) with the integrated basin management policy compared to without them (unpublished data). These results confirm that it is necessary to include minimizing T-N as an objective function when we formulate integrated policies to improve the water environment.

In this simulation, we found that if the basin management policy to introduce the new technologies is adopted in the catchment area, production by the pig farming industry would increase by about 448 million RMB Yuan over the 10 years of the simulation period compared with the scenario of not adopting the integrated basin management policy (unpublished data). Pig farming production increased more than 28.5% from 2007 to 2016 as compared with when the integrated basin management policy was not adopted. This result verified that the introduction of integrated basin management policy with introduction of new technologies is an effective way to reduce water pollution without deteriorating the socio-economic activity level and production of stockbreeding industry.

4. Conclusion

Adoption of an integrated basin management policy was a very effective tool for reducing environmental pollution in all simulations. Adoption of the policy with two new technologies raised the level of economic growth by 10% as compared with not adopting them. If we integrated policy was adopted in the catchment area, production by the pig farming industry would increase by about 448 million RMB Yuan over the 10 years of the simulation period compared with not adopting the integrated basin management policy with new technologies.

These results establish that introduction of integrated basin management policy allows the simultaneous pursuit of water environmental protection and economic development. This is a method for effectively enhancing food security, with coordination between environmental protection and economic development in order to contribute to sustainable development. This evaluation is expected to help improve biomass resource utilization and water environmental protection and form the basis of decision-making for sustainable development in the rural areas surrounding China's large cities.

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