



Situation and Treatment Methods of Ecological and Environmental Problems during the Process of Urbanization in Rural Areas of China

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ABSTRACT

Rural urbanization is a process of population agglomeration catalyzed by industrialization. At present, China's urbanization process is accelerating against the backdrop of rapid social development. However, in some areas, economic development is emphasized, while the protection of the ecological environment is neglected, leading to the increasingly obvious contradiction between urbanization and rural ecological environment and is not conducive to economic development. In this paper, the development trend of China's rural urbanization, the current situation of environmental pollution, and the progress of important environmental treatment projects are analyzed. Accordingly, the main problems in rural environmental protection and the impact of urbanization are explored. The problems led by industrial and domestic pollutants have been amplified by urbanization, while the improved connection between urban and rural areas will benefit the improvement of environmental infrastructure in rural areas. The government-led projects of rural water improvement, sanitary toilet penetration, methane gas production, and solar water heater have made great progress during the past two decades. Based on these understandings, we put forward feasible countermeasures to implement rural ecological environment protection during the process of urbanization to promote the benign development of rural urbanization. Our results will be helpful in providing some useful references for environmental protection in rural areas and promoting the coordinated development of the economy and environment during the process of urbanization in China.

INTRODUCTION

As one of the ancient civilizations in the world, China is the birthplace of human farming civilization and has always been a big agricultural country. Before China's reform and opening up in 1978, the original agricultural ecological environment was not eroded by modern civilization because agricultural production was always carried out in the traditional way. In the past 40 years, China's market economy has replaced the natural economy, and industrialized agricultural production has replaced primitive agricultural production. With the development of the rural economy, the degree of agricultural modernization has been accelerated unprecedentedly. However, the cost of economic and social development, industrialization, urbanization, and large-scale agricultural development have brought many direct or potential negative impacts on rural ecology and the environment.

Urbanization refers to the natural historical process in which social productive forces are transformed from traditional rural civilization to modern urban civilization in terms

of economic structure, population living, and population quality based on industrialization and informatization (Gibbs & Davis 1958, Gibbs & Martin 1958). From the late 1970s to the early 1990s, urbanization began to develop rapidly in China. In the following ten years, a total of 286 new cities emerged in China, and the population of cities also increased to 312.03 million, with the urbanization rate accounting for nearly 30%. During the process of urbanization and industrialization, the government usually pays more attention to economic growth and neglects environmental problems to a certain extent. However, the coordination between the economy and the environment is very important for sustainable development (Chen et al. 2019, Wu et al. 2021). The deterioration of the rural ecological environment restricts the sustainable development of villages and towns seriously and limits the potential for economic growth in rural areas. Due to the transfer of high-pollution industries from cities to surrounding villages, rural areas are usually faced with an increase in the proportion of industrial land during the process of urbanization, and thus being exposed to higher

environmental health risks (Zhang et al. 2021). In urbanized rural areas, the types of environmental pollution include traditional pollution, industrial pollution, and domestic pollution, and the sources of pollutants are diversified (Ou et al. 2020, Yang et al. 2019, Zhang et al. 2021, Zhu et al. 2019). Traditionally, rural environmental pollution mainly comes from productive sources such as pesticide pollution, chemical fertilizer pollution, and agricultural film pollution produced in agricultural production. The alteration of climate under the influence of the monsoon will limit the intensity of agricultural pollution discharge in the dry season (Xia et al. 2020a, Xia et al. 2019). During the process of urbanization, high-pollution industries move from cities to suburbs, urban-rural fringes, and rural areas, resulting in increased pollution of land, water, and air to varying degrees (Fang et al. 2015, Xia et al. 2020b, Xia et al. 2020c, Zhao et al. 2017). Domestic garbage, human and animal excrement constitute the main source of living pollution. The development of urbanization has promoted the circulation of people and goods in rural areas, and the amount of domestic waste has also increased greatly. In recent years, under the double pressure of increasing population and increasing industrial scale, the situation of China's rural environment is very severe. Although the government tries to solve the environmental pollution by means of technology, legal system, and economy, there are still many gaps in the research on comprehensive management of the rural environment (Yang 2010).

Therefore, it is of great significance to analyze the problems and causes of environmental pollution in rural areas and put forward corresponding solutions. This study summarizes the main environmental problems faced by China's rural areas during the process of urbanization systematically, analyzes the main sources of deteriorating environmental conditions, and sums up the main contents, research ideas, and corresponding technologies and methods of rural environmental pollution prevention and control research. Based on these understandings, this paper proposed some countermeasures to improve the environmental pollution control in rural areas of China and provides suggestions for building a sustainable economic and social development model.

MATERIALS AND METHODS

In this paper, based on results from previous research, combined qualitative and quantitative analyses are adopted. The current situation and main problems of rural environmental problems in China are analyzed based on references; the existing problems are analyzed by quantitative methods using the survey data. The development progress of urbanization in China is obtained through the spatial evolution of remote sensing images. The evolution of urbanization is judged

by land-use data. This data is collected from the "Remote Sensing Monitoring Database of Land Use Status in China" (LUCC) published by the Resource and Environment Data Cloud Platform of the Chinese Academy of Sciences. This data set is based on Landsat 8 remote sensing images and generated by manual visual interpretation. The grid accuracy is 1 km, and the land use is divided into 7 categories in this data set. "Industrial, mining and residential land" is regarded as a substitute index of the urban land use type. By analyzing the trend of some indicators of China's rural environment, corresponding solutions are put forward. Rural environmental data comes from China Environmental Statistics Yearbook published in 2018.

RESULTS AND DISCUSSION

Status of the Urbanization Process in Chinese Rural Areas: The past decades have witnessed the rapid development of China's rural urbanization. Urban expansion has played a remarkable role in promoting the development of surrounding rural urbanization. The distribution changes of working conditions and residential land in China from 1980 to 2015 are shown in Fig. 1. The scale change diagram of this land-use type is shown in Fig.2. In the past 30 years, the proportion of land uses related to cities has gradually increased, indicating the acceleration of urbanization. Generally, China's policy support for rural urbanization includes industry, planning, infrastructure, and community construction. With the improvement of the transportation system, urban-rural integration has been achieved in many areas. However, urbanization not only drives economic development but also increases rural environmental pollution. With the increase of population, the consumption and demand of resources will increase, and the emission of environmental pollution will also increase, thus the pressure of environmental governance will be greater. The rapid development of urbanization has driven a large number of township enterprises to be built in rural areas and become the main economic pillar of the local area. However, most township enterprises lack scientific planning and management, with a small scale of production and extensive management, and then produce a large amount of wastewater, gas, and residue. Enterprises usually pay attention to short-term economic benefits, but lack awareness of environmental protection. They do not bring in environmental protection facilities and supporting pollution treatment equipment, and the phenomenon of irregular sewage discharge is widespread. On the whole, the current situation of rural environmental pollution in the process of urbanization is grim. Although there have been partial improvements, the pollution problems in most areas have not been effectively rectified, and the environmental pollution problems in some areas even tend to worsen.

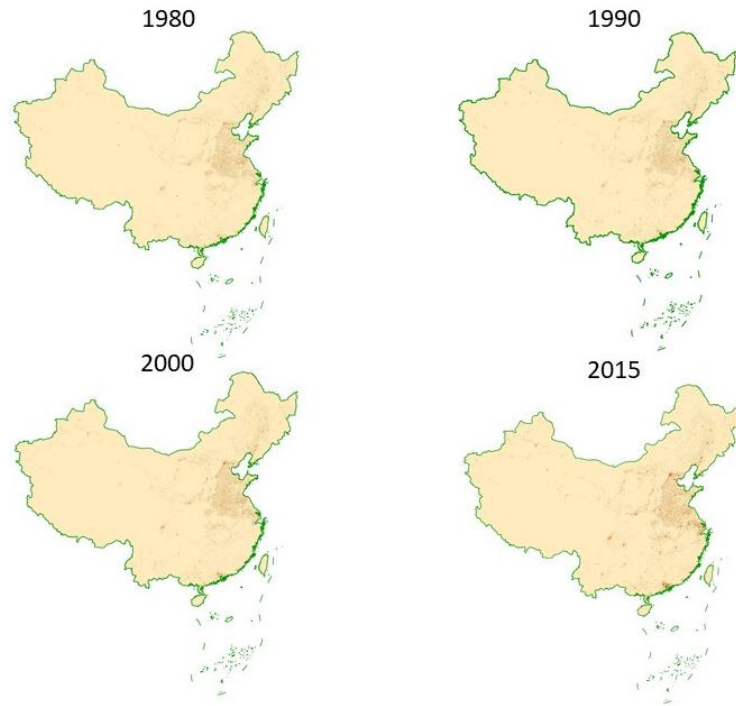


Fig. 1: Variation of the distribution of urban, mining, and residential land from 1980 to 2015. The red scatters represent this land-use type.

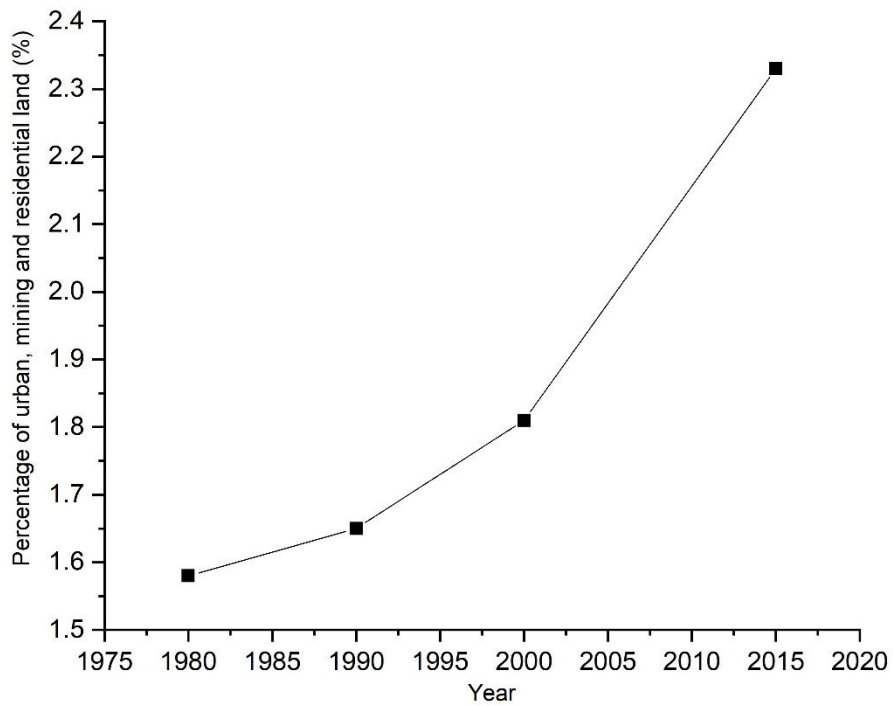


Fig. 2: Temporal variation of the ratio of urban, mining, and residential land in China.

Present Situation and Problems of Chinese Rural Environment: During the process of rural urbanization, the main environmental problems include two aspects: first, the environmental damage caused by ignoring the local natural conditions and disrespecting the objective laws of development. Second, the discharge of pollutants and wastes exceeds the self-purification capacity of the local environment due to the concentration of production and living activities, and the related infrastructure is difficult to keep up, resulting in environmental pollution problems. At present, under the background of increasing agricultural production efficiency and accelerating urbanization, the sources of rural environmental pollution are diverse and can be divided into the following four types:

1. **Agricultural pollution.** During the process of agricultural production activities such as planting, excessive or improper use of chemical fertilizers, pesticides, and plastic film causes pollution to soil and causes pollution to rivers and other water bodies indirectly. Incineration or random stacking of agricultural by-products will cause air pollution and soil pollution to varying degrees.
2. **Farming pollution.** Livestock manure, aquaculture wastewater, and aquaculture sludge contain a large amount of nitrate, phosphorus, sulfide, ammonium, carbohydrate, etc. Among them, nitrate and phosphorus will lead to the large-scale growth of phytoplankton, which will gradually cover the water surface reducing the content of dissolved oxygen in water, and further leading to the death of aquatic plants and aquatic animals. These will finally make the water stink and rot and threaten people's health.
3. **Domestic-source pollution.** Due to the imperfect basic public facilities in rural areas, the sewage produced by residents in their lives, as well as the feces and urine of people and animals, are discharged directly into nearby rivers without any treatment, leading to pollution phenomena such as the odor of water bodies. In addition, urban garbage is usually transported to open areas in rural areas to be buried and piled up. Without any treatment measures, the garbage will gradually pollute the surface water and groundwater, resulting in serious groundwater pollutions.
4. **Industrial and mining pollution.** During the process of urbanization, a large number of industrial enterprises have transferred high-pollution production lines to rural areas. However, the rural environment has been seriously polluted by industry due to the weak control and supervision of environmental protection in rural towns, and a huge amount of waste gas, residue, and gas have been wantonly discharged, which has become

an important cause of the increasingly serious environmental pollution in rural areas.

Serious pollution is extremely harmful to the rural ecological environment. Traditional agricultural pollution affects the quality of cultivated land and leads to serious desertification. Long-term use of pesticides and fertilizers has seriously damaged the balance of soil nutrients, and the random stacking of domestic and production garbage has brought impacted soil physical and chemical properties. With the advancement of rural urbanization, urban pollution gradually migrates to rural areas, the number of heavy metal pollutants and toxic substances discharged by industry is increasing, leading to the decrease in the number and types of animals and plants. Many rare species have disappeared, which has brought serious damage to the ecological balance and the development of biodiversity.

In China's rural areas, an effective supervision and inspection system has not been established, nor has a perfect garbage removal system been formed. Most of the generated domestic and production wastes are discharged in rivers, seas, and lakes, or stacked directly on the roadside, and they cannot be recovered and treated in time and effectively. Additionally, the education level of Chinese farmers is generally low, and many farmers do not realize the deep harm caused by environmental pollution and the significance of resource protection. Therefore, it is difficult to change their production and living habits. The residents lack the subjective will to participate in pollution control, which limits the development of rural environmental protection.

Measures for Rural Environmental Protection: Currently, the Chinese government attaches great importance to the problem of rural environmental pollution and carries out comprehensive improvements in rural areas. The main measures of environmental governance promoted in rural areas include strengthening the harmless and resource treatment of rural garbage, promoting macro-control and prevention of livestock and poultry breeding pollution, vigorously developing agricultural clean production technology and clean energy, strengthening the management of township enterprises and reducing industrial pollution, and rectifying domestic garbage pollution. For agricultural pollution, the management department promotes clean production technology actively in the process of agricultural planting and processing in the vast rural areas to eliminate the traditional pollutants in rural areas effectively. They also promote the use of low-toxic pesticides and organic fertilizers in the planting process, avoid excessive use of chemical fertilizers and pesticides, and adopt planting varieties with strong insect and disease resistance. Moreover, the financial department increased investment in clean energy and infrastructure and

encouraged rural areas to use solar energy and electricity generated by small hydropower for lighting, heating, and cooking. Construction of biogas digesters is concentrated in breeding and straw production areas, and biogas is produced from collected animal excreta and discarded straw to meet the daily needs of farmers. Rural water improvement projects, sanitary toilet extension projects, biogas production projects, and solar water heater construction projects are representative environmental protection construction projects in rural China in recent years. The development of these four types of projects is shown in Fig. 3. Rural water improvement project focuses on the scientific supply of rural drinking water and aims at ensuring the drinking water safety of rural residents, which is the most important project in rural environmental remediation. Rural water improvement project has been promoted rapidly in recent years and has been basically completed (Fig. 3a). Sanitary toilet extension project aims to achieve the harmless transformation of rural household toilets by the treatment or resource utilization of toilet manure and improvement of rural domestic sewage treatment rate. The popularization rate of sanitary toilets increased from less than 45% in 2000 to about 85% in 2017, and the indiscriminate discharge of rural domestic sewage

was effectively controlled (Fig. 3b). Biogas production increased rapidly from 2000 to 2012 and then began to decline after reaching its peak in 2012 due to the fact that natural gas pipelines began to be laid in rural areas, which was beneficial to further improve energy utilization efficiency (Fig. 3c). The coverage area of solar panels in rural areas increased nearly nine times from 2000 to 2017. Compared with the common coal-fired heating, solar water heaters have the advantages of environmental protection and energy-saving, which can significantly reduce ecological environmental pollution and increase energy utilization rate, and exhibit great potential in rural sustainable energy utilization.

Suggestions for Further Efforts on Rural Environment Protection: Although in recent years, China's rural ecological environment problems have been alleviated in some aspects due to the attention of management and the progress of science and technology. However, there are still many shortcomings. The root causes of these problems mainly include farmers' weak awareness of environmental protection, unreasonable resource structure, insufficient environmental supervision, and insufficient investment in environmental pollution control funds. To further improve the rural environment, the following suggestions are put forward:

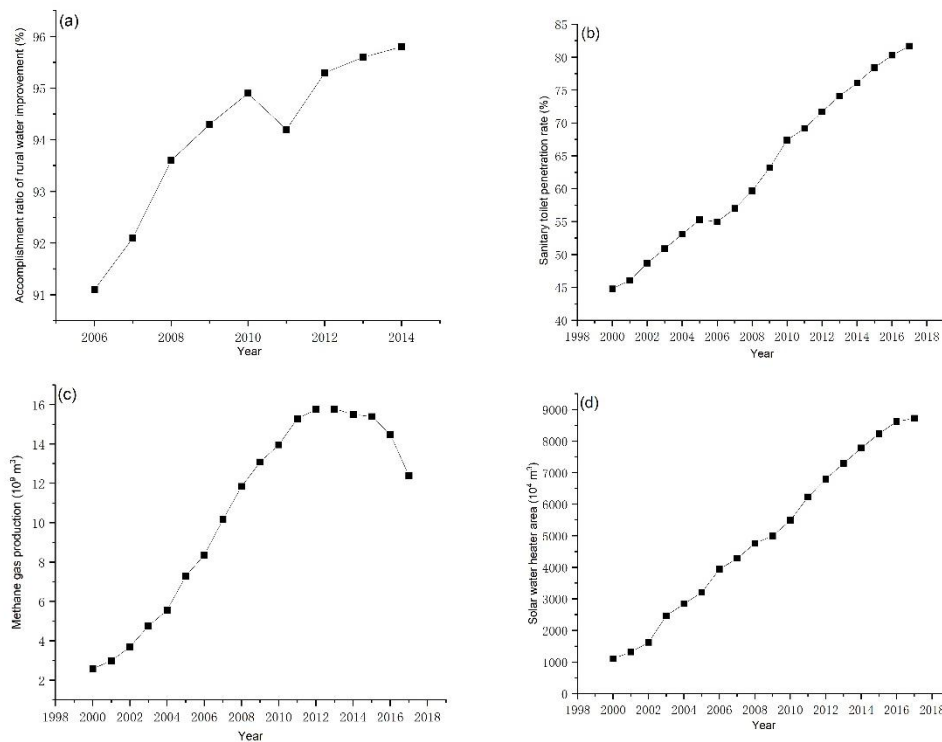


Fig. 3: Variation of environmental protection facilities in China. Panels a, b, c, and d represent the trends of rural water improvement, sanitary toilet penetration, methane gas production, and solar water heater, respectively.

1. Developing ecological agriculture. The promotion of ecological agriculture is the primary measure to improve the rural environment. The vigorous development of ecological agriculture requires the rational development and utilization of existing ecological resources in agriculture, the close combination of ecological benefits and economic benefits, and the optimization of China's agricultural structure. On the one hand, it is necessary to pay equal attention to grooming and governance. The local government needs to guide farmers to develop organic ecological agriculture, reduce the amount of chemical fertilizers and pesticides, reduce man-made pollution, and prohibit the destruction of plants and deforestation. On the other hand, the relevant departments should take inclined measures, invest funds to help farmers to change toilets and circles, build biogas digesters and other pollution reduction engineering measures, and reduce the discharge of domestic and aquaculture sewage fundamentally.
2. Strengthening the propaganda of environmental protection. Improving rural residents' awareness of environmental protection is a fundamental measure to solve the problem of rural environmental pollution in China. Under the background of the Internet age, local governments can use the combination of new media and traditional media as an instrument to carry out environmental protection propaganda, popularize rural environmental protection knowledge, and strengthen environmental protection legal education. The government and the community should pay attention to cultivating residents' awareness of garbage recovery and treatment, and promote ecological education for residents.
3. Promoting the construction of environmental protection facilities. The government should increase investment in rural environmental protection and strengthen infrastructure construction vigorously. On the one hand, it is necessary to promote the centralized collection of rural garbage and the construction of harmless physical facilities. The garbage transfer stations can be established in towns or villages, and all kinds of garbage should be transported to the transfer stations regularly, and then transported to the garbage treatment plants in a unified way. On the other hand, rural sewage treatment is needed to be actively carried out. It is important to adopt a combined measure of decentralized and centralized treatment to comprehensively treat domestic sewage, and actively promote the scientific treatment mode of domestic sewage.
4. Developing the legal system of rural environmental protection. On the whole, the current rural environmental

protection laws and regulations system is still far from perfect and lacks operability. In addition, there are still legal gaps in many areas of the rural environment and resource protection in China. Therefore, it is necessary to gradually establish and improve laws and regulations on the rural environment, strengthen environmental law enforcement and supervision, and protect the rural environment from the level of the legal system. Based on national laws and regulations, it is suggested that localities further formulate local supporting laws and regulations for rural areas according to their own environmental pollution characteristics to fill the legal gaps. In rural areas with rapid urbanization, on the one hand, it is important to deal with the environmental problems from traditional agricultural production, such as livestock and poultry pollution, rural pesticide, fertilizer, agricultural film pollution, domestic garbage, domestic sewage, and other issues. On the other hand, the rectification and standardization of the sewage discharge of key township enterprises is also a challenge for local government.

CONCLUSIONS

In this paper, China's current rural urbanization process is summarized, and various environmental problems in the related rural urbanization development process are analyzed in detail. Countermeasures are put forward for various environmental problems in the current development process. On the one hand, urbanization has increased the types and sources of pollutants in China's rural areas and aggravated the deterioration of the ecological environment. Traditional agricultural pollution and industrial and domestic pollution introduced by urbanization have made rural environmental governance more complicated. On the other hand, urbanization is conducive to urban-rural connectivity and is helpful in promoting rural infrastructure construction and accelerating the development of the environmental protection industry. In the past decades, China's rural environmental improvement has been promoted rapidly, and some achievements have been made in energy conservation and environmental protection. The rural water improvement project, sanitary toilet extension project, biogas production project, and solar water heater construction project have made remarkable progress in rural areas. However, there are still many blanks. It is of great significance for the government and community to strengthen the protection of rural ecology and environment by means of technology popularization, publicity and education, and legal means to accomplish the harmonious development of urbanization construction and ecological environment protection, which will lead to the sustainable development of the rural economy.

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