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Characteristics of Surface Water Quality Affected by Agricultural Non-point Sources in Guigang City

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Abstract [**Objectives**] To analyze the influence characteristics of surface water quality by agricultural non-point sources in Guigang City of Guangxi. [**Methods**] The daily concentration series of water quality indicators at three state-controlled monitoring stations in Guigang City from 2019 to 2021 was analyzed by using Daubechies (db) wavelet, and Morlet wavelet was used to analyze the daily average concentration of water quality indicators. Continuous wavelet transform (CWT) was used to analyze the monthly concentration series of water quality indicators at three state-controlled monitoring stations in Guigang City from 2014 to 2021. [**Results**] The Daubechies (db) wavelet analysis showed that the concentrations of COD_{Mn}, TP, and TN had the maximum values during June – July and October – November, and there were spatial differences among monitoring stations (COD_{Mn} concentration exceeding the standard was the most serious in Shizui, and DO concentration not up to standard was the most in Thermal Power Plant, and NH_3-N, TP and TN exceeding the standard was the most in Wulin Ferry). Morlet results showed that principal period of wavelet variance graphs of COD_{Mn}, NH_3-N, and TP was 340 d, and there was the same sub-period of 140 d, and principal period of wavelet variance graph of DO was 260 d. CWT results showed that COD_{Cr} had similar resonance periods of about 1 – 2 and 5 – 7 months; BOD_5 and COD_{Mn} was dominant by the resonance period of 1 – 4 months (2014 – 2017); DO had a similar resonance period of about 1 – 3 months; NH_3-N was dominant by the resonance period of 1 – 5 months. [**Conclusions**] The surface water quality of Guigang City was mainly affected by the residual nitrogen and phosphorus nutrients and pesticide residues from agricultural production activities.

Key words Water quality, Daubechies (db) wavelet, Morlet wavelet, Continuous wavelet transform (CWT)

1 Introduction

All rivers in Guigang City belong to the Xijiang River system of the Pearl River basin. The main rivers are the Yujiang River, the first level tributary of the Xijiang River, and the Qianjiang and Xunjiang sections of the main stream of the Xijiang River. As the main grain production and aquaculture bases in Guangxi Province, the Yujiang River and the Xunjiang River have maintained the decentralized traditional agricultural production mode for a long time, and a large amount of chemical fertilizers and pesticides have been applied and various kinds of bait have been put in. The non-point source pollutants such as surplus nitrogen and phosphorus nutrients and pesticide residues from agricultural production activities will become the main threat to the water ecological environment in Guigang area, which has long existed and is difficult to be effectively treated. At present, there are relatively few studies on the change trend and causes of pollutants in the Xijiang River system of South China. In this paper, the Yujiang River and Xunjiang River in Guigang City were taken as examples to study the space-time distribution and causes of surface water in South China. Wavelet analysis method was used to analyze the scale of pollution change and mutation period.

2 Data and methods

There are three state-controlled monitoring stations in the Yujiang River and the Xunjiang River, including Thermal Power Plant (Gangbei District), Shizui (Guiping City) and Wulin Ferry (Pingnan County). The geographical distribution was shown in Fig. 1. The separation data (monthly concentration) collected by the state-controlled monitoring stations from 2014 to 2021 came from the Guigang Environmental Monitoring Center and the Urban Monitoring Station of the Guigang Ecological Environment Bureau. The automatic monitoring data (daily concentration) of the state-controlled monitoring stations from 2019 to 2021 came from the surface water management platform of Guigang City (Guigang Ecological Environment Bureau). The water quality shall be determined according to the *Environmental Quality Standard for Surface Water* (GB 3838-2002) or the corresponding standard limit, and the assessment method shall be in accordance with the *Environmental Quality Assessment Method for Surface Water* (*Trial*) (HB [2011]22).

3 Results and analysis

3.1 Temporal and spatial distribution of water pollutants by db wavelet analysis Based on the physical and chemical characteristics of surface water pollutants themselves, according to the consistency and difference for temporal change trend of daily concentration of water quality indicators, combined with the geographical location and emission characteristics of pollution source enterprises, agricultural production activities and other factors, the spatial distribution characteristics of pollutants were analyzed, and the source of pollutants was attempted to be traced.

Fig. 2a was reconstruction diagram of time series high-fre-

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quency component (D3) of COD_{Mn}, DO, NH_3-N, TP, and TN at Thermal Power Plant State-controlled Monitoring Station during 2019 – 2021. Thermal Power Plant State-controlled Monitoring Station is located in Wule Town, Gangbei District, outside the North Ring Road of Guigang City, which is subordinate to the Yujiang River. There are many industrial plants around it. The large municipal controlled sewage discharge source is Guangdong – Guangxi Industrial Park, which has a sugar factory, a thermal power plant, a paper factory, and a pulp factory. The temporal variation trend of COD_{Mn}, TP and TN in thermal power plant was relatively close, showing three obvious cycles, corresponding to the high concentration from June to July and October to November. The surrounding crops were planted in a two-cropping system, and the high concentration value corresponded to the peak period of crop growth, indicating that the pollution source was mostly agricultural fertilizer. Among them, TP concentration from June to August of 2019 had a peak in the three years. DO fluctuated greatly throughout the year without obvious cycle. NH_3-N did not change significantly, and its content was relatively low, with obvious fluctuation in October 2021. The presence of N elements in surface water was mostly organic nitrogen or nitrate nitrogen. When dissolved oxygen in water was sufficient, NH_3-N was easily oxidized to nitrate by nitrifying bacteria.

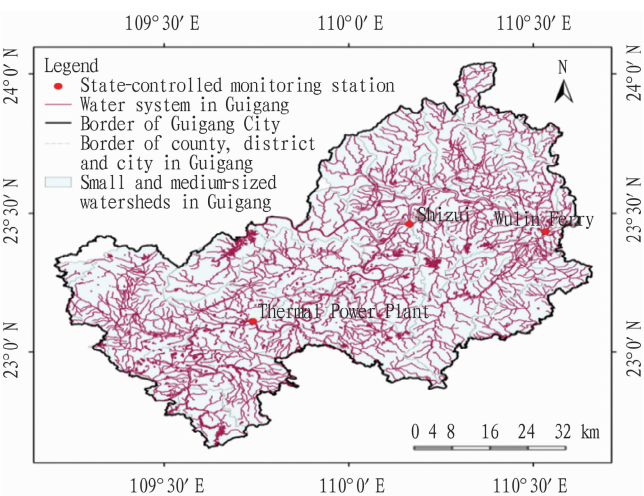
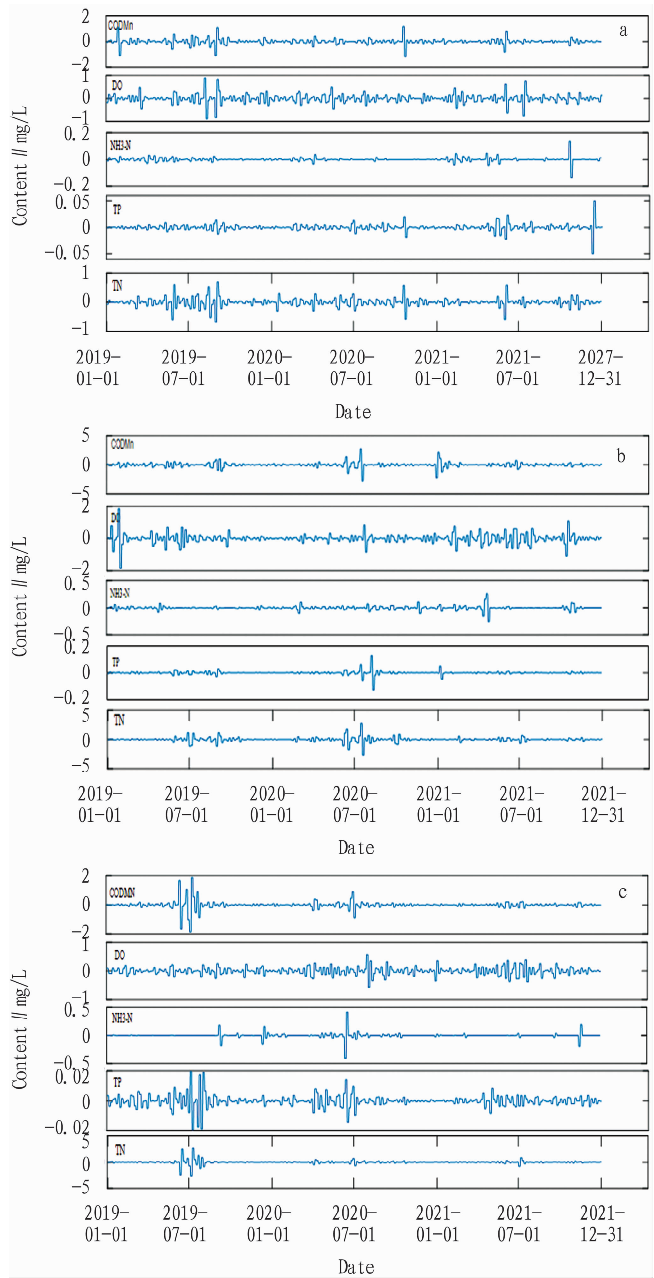


Fig. 1 Distribution of state-controlled monitoring stations in the Yujiang River and the Xunjiang River

Shizui State-controlled Monitoring Station is located in Shizui Town of Guiping City, and is subordinate to the Xunjiang River, surrounded by farmland. Guangxi Jinyuan Biochemical Industry Co., Ltd. and Sewage Treatment Plant of Chang'an Industrial Zone of Guiping City, the municipal controlled sewage pollution sources in 2019, were located at the upstream of the Xunjiang River, about 10 km away from Shizui Monitoring Station. Seen from Fig. 2b, COD_{Mn}, TP and TN at Shizui Station had a high concentration with the same frequency of fluctuation from June to July 2020, which gradually decreased and became stable after 2021. This was due to the strict supervision of the government departments on Guangxi Jinyuan Biochemical Industry Co., Ltd. and Sewage Treatment Plant of Chang'an Industrial Zone of Guiping City, and the sewage was steadily discharged up to the standard. The fluctuation of NH_3-N was not obvious, and there was a relatively obvious fluctuation in May and October 2021. At this time, DO was sufficient, which may be due to the increase of NH_3-N by the decomposition of organic nitrogen fertilizer.



Note: a. Thermal Power Plant; b. Shizui; c. Wulin Ferry.

Fig. 2 Reconstruction of high-frequency component (D3) of surface water pollutant index

Wulin Ferry State-controlled Monitoring Station is subordinate to the Xunjiang River, located in Wulin Town of Pingnan, and surrounded by farmland. About 18 km upstream, there is a municipal controlled sewage discharge source, Pingnan Keda Water Co., Ltd. Fig. 2c showed that the contents of COD_{Mn}, TP and TN at Wulin Ferry Station were relatively high from June to July 2019, with obvious fluctuations, rising and falling at the same time, indicating that the sources of pollutants were consistent. It was expected to be affected by the upstream sewage discharge sources and spring crop fertilization. Since 2020, the contents of COD_{Mn}, TP and TN have been decreasing year by year. In 2021, there was basically no obvious fluctuation, and the water quality has been improved significantly, which was due to the government's efforts to standardize the monitoring and treatment of enterprise wastewater.

3.2 Morlet wavelet analysis results of water pollutants Morlet wavelet analysis was used to analyze the daily concentration series of five water quality indicators (COD_{Mn}, DO, NH_3-N, TP, TN) at the state-controlled monitoring stations from 2019 to 2021, to deeply explore the change characteristics of surface water pollutants in Guigang City[6-7].

Fig. 3 showed the interannual scale change, mutation point distribution and phase structure of daily average concentrations of COD_{Mn}, DO, NH_3-N, TP and TN in Guigang. The size of the concentration was reflected by the wavelet coefficient. The larger the wavelet coefficient was, the greater the concentration value was. In Fig. 3a, the interannual variation trend of COD_{Mn} daily average concentration data from 2019 to 2021 analyzed by Molet wavelet was consistent with that of Daubechies (db) wavelet. The highest value of COD_{Mn} content occurred in the wet season (April to September) every year. The main period of COD_{Mn} wavelet variance diagram was 340 d, and the sub-period was 150 and 100 d. In Fig. 3b, the interannual variation trend of DO daily average concentration data had the maximum during the dry season (October to next March), indicating that the water quality was good. The main period of DO wavelet variance diagram was 260 d, and the sub-period was 140 d. The high values of the interannual variation of NH_3-N daily average concentration data were in winter and spring (January to June) of 2019 to 2020, summer and autumn (July to October) of 2021, and the NH_3-N concentration in water quality showed the signs of reduction in 2021. The main period of NH_3-N wavelet variance diagram was 340 d, and the sub-period was 140 and 50 d. The interannual variation of the daily average concentration data of TP and TN was similar to that of NH_3-N, and the concentration had a downward trend by 2021. The main period of TP wavelet variance diagram was 340 d, while the main period of TN wavelet variance diagram was 340 d, and the sub-period was 140 d. The reason was that the crops grew seasonally in the wet season, and chemical fertilizers and pesticides were frequently used, and then most of the unabsorbed chemical fertilizers and pesticides were discharged into the river water body through runoff through rainwater scouring. Especially the wavelet coefficient diagrams and variance diagrams of NH_3-N, TP, TN were similar, indicating that the pollution sources were of the same origin.

3.3 Continuous wavelet transform (CWT) analysis results of water pollutants Matlab software was used to carry out continuous wavelet transform (CWT), to analyze the periodic characteristics of monthly concentration series (collected separation data) of the six indicators at the state-controlled monitoring stations from 2014 to 2021: chemical oxygen demand (COD_{Cr}), biochemical oxygen demand (BOD_5), potassium permanganate index (COD_{Mn}), dissolved oxygen (DO), ammonia nitrogen (NH_3-N), and total phosphorus (TP). CWT results of each station in Guigang area were analyzed. In Fig. 4, there were two significant resonance periods of COD_{Cr} in the Thermal Power Station, which were 1 - 2 months (2015, 2019, 2021) and 5 - 7 months (2015), dominant by the period of 5 - 7 months (2015). BOD_5 had two significant resonance periods: 1 - 4 months (2014 - 2015) and 4 - 6 months (2015), dominant by the period of 1 - 4 months (2014 - 2015). COD_{Mn} had a significant resonance period, which was 1 - 4 months (2014 - 2016). DO had 3 significant resonance periods, which were 1 - 3 months (2015), 2 - 7 months (2017 - 2020), and 1 - 2 months (2021), dominant by the period of 2 - 7 months (2017 - 2020). NH_3-N had 2 significant resonance periods: 1 - 5 months (2016) and 8 - 10 months (2016), dominant by the period of 1 - 5 months (2016). TP had 2 significant resonance periods: 1 - 2 months (2014 - 2015) and 2 - 5 months (2016), dominant by the period of 2 - 5 months (2016).

There were three significant resonance periods for COD_{Cr} in the power spectrum of water quality index in Shizui: 1 - 2 months (2015), 1 - 3 months (2017), and 5 - 8 months (2019 - 2020), dominant by the period of 5 - 8 months (2019 - 2020). BOD_5 had 3 significant resonance periods: 1 - 2 months (2015), 1 - 4 months (2017), and 5 - 7 months (2017), dominant by the period of 5 - 7 months (2017). COD_{Mn} had 2 significant resonance periods: 1 - 4 months (2015) and 2 - 3 months (2016), dominant by 1 - 4 months (2015). DO had 3 significant resonance periods: 4 - 7 months (2015), 1 - 3 months (2017), and 9 - 12 months (2017 - 2020), dominant by the period of 9 - 12 months (2017 - 2020). NH_3-N had 3 significant resonance periods: 1 - 2 months (2015), 2 - 5 months (2015), 1 - 5 months (2017), dominant by 1 - 5 months (2017). TP had a significant resonance period, which was 1 - 8 months (2017).

In power spectrum of water quality index in Wulin Ferry, COD_{Cr} had 3 significant resonance periods: 4 - 5 months (2014), 2 - 6 months (2017 - 2019), and 5 - 7 months (2020), dominant by the period of 2 - 6 months (2017 - 2019). BOD_5 had 2 significant resonance periods: 1 - 4 months (2017) and 4 - 6 months (2021), dominant by the period of 1 - 4 months (2017). COD_{Mn} had a significant resonance period, which was 1 - 6 months (2015). DO had 2 significant resonance periods: 1 - 3 months (2017 and 2020) and 10 - 15 months (2017 - 2020), dominant by the period of 10 - 15 months (2017 - 2020). NH_3-N had a significant resonance period, which was 1 - 4 months (2015). TP had 2 significant resonance periods: 1 - 2 months (2015 and 2019) and 1 - 4 months (2017), dominant by the period of 1 - 4 months (2017).

There were similar resonance periods of about 1 – 2 and 5 – 7 months for COD_{Cr} in Thermal Power Plant, Shizui and Wulin Ferry, and the periods of occurrence at each station were different. BOD_5 and COD_{Mn} had the main period of 1 – 4 months (2014 – 2017) and the sub-period of 4 – 6 months, and the occurrence time was different. DO had similar resonance period of about 1 – 3 months, and they respectively occurred in 2015, 2017 and 2020, and longer main period occurred in 2017 – 2020. NH_3-N was dominant by the period of 1 – 5 months, and they respectively occurred in 2015 – 2017. Main period of TP occurred in 2016 – 2017, and the sub-period was 1 – 2 months, and the occurrence time was uncertain. In general, the three state-controlled monitoring stations had multi-scale significant periodic fluctuations, and the short-term change was the main one.

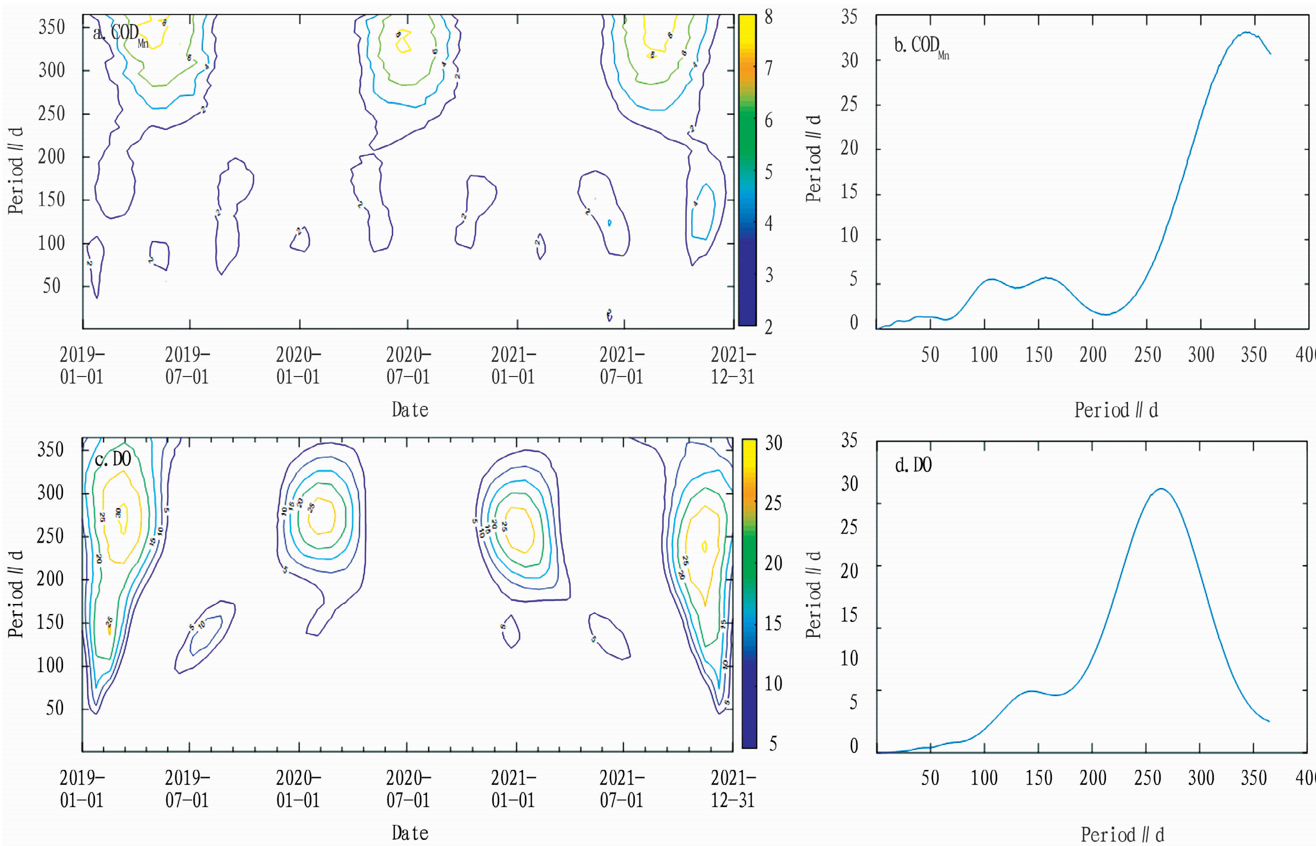


Fig. 3 Wavelet coefficient diagram and wavelet variance diagram of daily concentration of COD_{Mn} and DO with a scale of 365 d

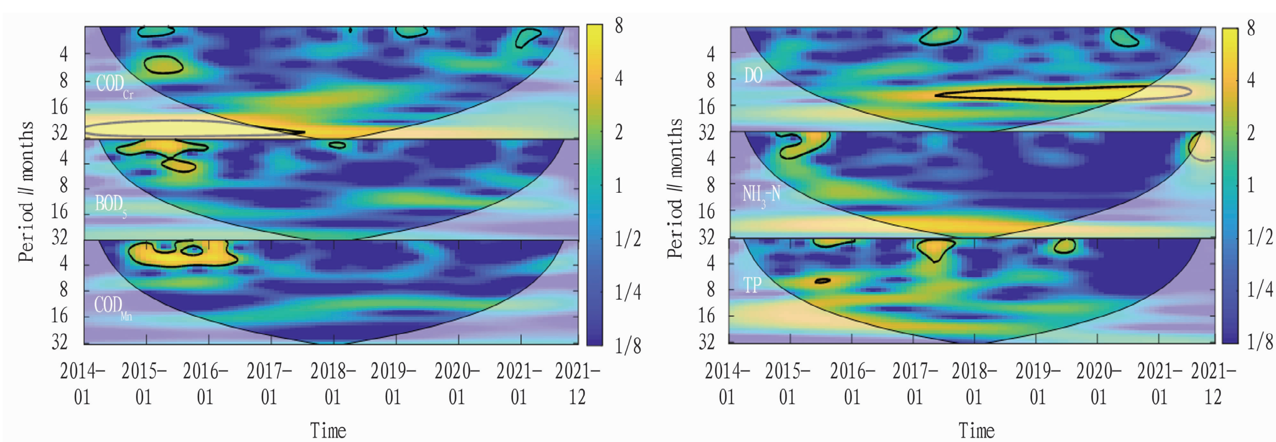


Fig. 4 Power spectrum of water quality index of Thermal Power Station

4 Conclusions

Temporal distribution of water pollutants using db wavelet: the concentration of COD_{Mn}, TP, and TN had the peak during June – July and October – November, and gradually reduced and stabilized after 2021. This was due to the strict supervision of chemical enterprises and sewage treatment plants by government departments. Spatial distribution of water pollutants in case of pollution: COD_{Mn} concentration exceeding the standard was the most serious in Shizui; DO concentration not up to standard was the most in Thermal Power Station; exceeding times of NH_3-N, TP and TN was the most in Wulin Ferry. The four sub-stations also had common features: the water quality indicators generally declined and tended to be stable in 2021.

The daily average concentration series of COD_{Mn}, DO, NH_3-N, TP and TN was analyzed by Morlet wavelet, and the interannual variation trend was more consistent with that of db wavelet. The main period of wavelet variance diagram of COD_{Mn}, NH_3-N and TP was 340 d, and the same sub-period was 140 d, and the main period of wavelet variance diagram of DO was 260 d.

There were similar resonance periods of about 1 – 2 and 5 – 7 months for COD_{Cr} in Thermal Power Plant, Shizui and Wulin Ferry, and BOD_5 and COD_{Mn} had the main resonance period of 1 – 4 months (2014 – 2017). There was similar resonance period of about 1 – 3 months for DO, and NH_3-N had the main resonance period of 1 – 5 months. The three state-controlled monitoring stations had multi-scale significant periodic fluctuations, and the short-term change was the main one.

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improve the socialized collection mechanism of floating population information, further strengthen the management and service, comprehensively integrate the forces of all social parties, and effectively solve the current situation of weak management strength.

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