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Analysis of hazardous waste based on GIS

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Abstract: *The increasing production of hazardous waste and the imbalance of regional disposal capacity are more and more prominent in the contradiction between industrial development and environmental protection. His paper takes the production of hazardous waste as the research object, combined with the geographic information system, and based on the regional difference and institutional density of hazardous waste [1], starting from the production of hazardous waste in each province, reveals the temporal and spatial evolution law of hazardous waste production in China, and explores the potential gathering areas of high-risk hazardous waste and their site selection in the future. Based on the hazardous waste disposal capacity of each province, the production of hazardous waste in the next five years in the high-high-type regions was predicted by using the Holt-Winters model fitting prediction model [2]. The results show that there is no significant spatial autocorrelation of hazardous waste production in China. As can be seen from the local accumulation characteristics of hazardous waste production in each province, the high-high type is mainly concentrated in the eastern coastal area. During 2011-2019, the number of high-high type significant hot spots increased from 1 to 4.In the next five years, the production of hazardous waste in high-high-type regions will continue to increase, and it may move to the direction of decline in Shandong Province. Based on the weighted factor method, the proposed optimal location of hazardous waste treatment plant is located in Yancheng City, Jiangsu Province.*

Keywords: *GIS, Spatiotemporal evolution, Prediction, Site selection*

1. Background

With the acceleration of the industrialization process, the hazardous waste discharged during the production process is increasing, especially the outbreak of the new crown pneumonia in 2020, which has caused a sudden increase in the output of medical waste in my country. The substantial increase in the overall amount of hazardous waste has led to the rapid release of the demand for hazardous waste disposal. Although the domestic research on hazardous waste has made great progress, most of its development is to study the hazard awareness, identification standards, management regulations, comprehensive utilization of hazardous waste, etc. However, there are fewer studies on how to efficiently respond to the social status quo of increasing hazardous waste in various provinces in China, so that it can be prevented in advance.

2. Model Establishment

2.1 Global spatial autocorrelation

The global spatial autocorrelation is used to analyze the spatial dependence pattern of the entire region, and use a value to reflect the global spatial correlation pattern. The global Moran statistics measure the similarity between the high and low levels of hazardous waste production in various provinces and cities, and are used to reflect the degree of aggregation of hazardous waste production in various provinces and cities across the country.

The global Moran statistics definition is:

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$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\omega_{ij}(x_i-\bar{x})(x_j-\bar{x})}{S^2\sum_{i=1}^{n}\sum_{j=1}^{n}\omega_{ij}}$$

2.2 Local spatial autocorrelation

Combining the local Moran's Ⅰ index and LISA cluster map to measure the hazardous waste production in various provinces and cities across the country from 2011 to 2019 in a local space. The Moran scatter plot depicts the relationship between the output of hazardous waste in various provinces and cities across the country and the spatial lag [3]. The four types of high-high, low-high, high-low, and low-low are located in the four quadrants of the scatter plot.

The definition of local Moran index is:

$$I_i = z_i\sum_{j=1}^{n}w_{ij}z_j$$

2.3 Holt-Winters model

Holt-Winters method is a time series analysis and forecasting method. This article uses annual data. This method is divided into addition model and multiplication model. The additive model is also called the additive seasonal model. It is assumed that the trend component $\{x_t\}$ of the time series μ_t and the seasonal component s_t are additive. In the ideal case $x_t=\mu_t+s_t$, μ_t linearly increases with time, and s_t is the seasonal component of cycle T. In addition, there may be irregular noise components in x_t.

2.4 Weighted factor method

The process of weighted factor analysis is roughly divided into five steps: determining influencing factors, giving weights, scoring according to levels, calculating the scores of each plan, and comparing the best plan [4].

There is a multi-objective decision-making problem with m influencing factors including $f_1(x), f_2(x),\cdots f_m(x)$, and factor $f_i(x)$ is assigned a weight coefficient of $\lambda_i(i=1,2\cdots m)$ to form an objective function:

$$max\,F(x)=\sum_{i=1}^{m}\lambda_i f_i(x)$$

2.5 Temporal and spatial evolution of hazardous waste production in China

Through the data collation of hazardous waste production in various provinces of China from 2011 to 2019 and the processing of outliers, based on the macro data of hazardous waste production in China in 2011, 2013, 2016, and 2019, using the R language visualization method Investigate the appearance characteristics of the geographical distribution of hazardous waste production in various provinces and cities.

In order to effectively measure the high and low correlation of the spatial concentration of hazardous waste production in China's provinces and cities, the global statistics of hazardous waste production in China's 31 provincial administrative regions were calculated and tested in this paper (Table 1).

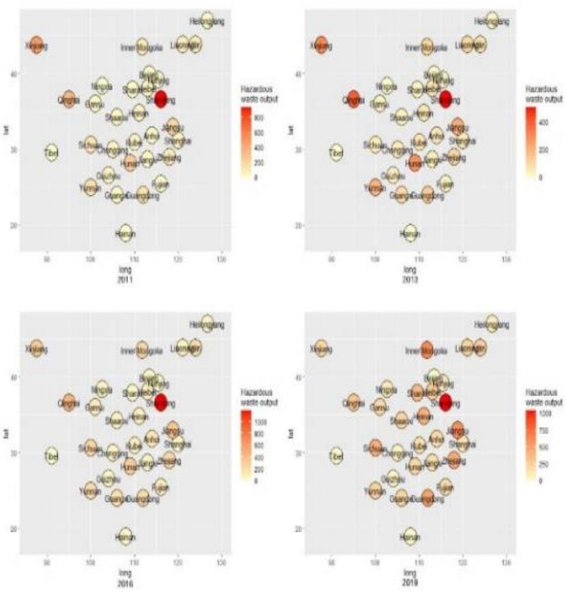

Figure 1: Representation distribution

Table 1: Global statistics

time	Moran's I	P	Z
2011	-0.0118	0.351	0.1998
2012	0.0065	0.28	0.4324
2013	-0.0086	0.347	0.2602
2014	-0.0177	0.377	0.1886
2015	-0.0091	0.367	0.2052
2016	-0.0012	0.342	0.3303
2017	0.0137	0.191	0.8633
2018	0.0222	0.143	1.0457
2019	0.0219	0.259	0.5872

2.6 Combination forecasting model combining Moran's Ｉmodel

Through the time series diagrams of various hazardous waste impact indicators, it is found that the dimensions of different indicators have misleading effects on the observation of the data. Therefore, the variables are smoothed to obtain the logarithmic data indicator discovery. The logarithmic response variable (hazardous waste there is an obvious linear relationship between output) and the eight explanatory variables. And since 1990, all data have been on the rise. Thus, the logarithmic fitting model of hazardous waste is established:

$$\ln y_t = \beta_0 + \beta_1 x_{1t} + \cdots \beta_8 x_{8t} + \varepsilon_t$$

The parameters of the initial regression equation were estimated by Eview10.0, and it was found that there was a problem of multicollinearity among the explanatory variables of the fitted model. The explanatory variable $x_7, x_1, x_2, x_6, x_5, x_8$ was sequentially added through the stepwise regression method to obtain the best fitting model, which was at a significance level of 0.05 the fitting model passed the significance test, and the parameters were significantly non-zero. The goodness of fit was $R^2 = 0.9784$, and the fitting effect was good; the White test of the model found that $Obs * R - squared = 20.7829$ corresponds to $\mathrm{P} = 0.1870 > 0.05$. In addition, the White statistic was $nR^2 = 20.78$, from the chi-square The distribution table found that at the 5% significance level, the critical value of the chi-square distribution with 16 degrees of freedom is 26.3>20.78, and the null hypothesis of homoscedasticity is accepted, that is, the model does not have heteroscedasticity problems; at the same time, 1- The 5-order Lagrangian multiplier test found that there is no serial correlation, and it can be considered that the model does not have serial correlation, that is, the optimal model is:

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$$\ln \hat{y} = 301.66 - 2312\ln x_1 + 3.06\ln x_2 - 2.25\ln x_5 - 1.24\ln x_6 + 2.95\ln x_7 - 1.91\ln x_8 + \varepsilon_t$$

2.7 Model prediction

The article takes the total population of Shandong as an example to carry out the univariate fitting and forecasting process. According to its data characteristics, finally set the Holt-Winters model parameters: gamma=F,l.start=8493,b.start=77 . And make numerical predictions for the next five periods.

After calculation, the regression equation obtained by fitting the hazardous waste production from the nationwide statistical data, the model passed the F test at a significance level of 0.05, and each parameter was significantly non-zero. The goodness of fit is $R^2 = 0.9917$, the combined effect is good.

$$\hat{y} = 93.58 + 0.075x_1 + 0.027x_2 - 0.12x_3 - 0.009x_4 - 374x_5 - 0.0038x_6$$

2.8 Results

Calculate the final score of each city based on $F(x_i) = \lambda_i f(x_i)$. The higher the overall score, the more suitable the city is as a site for hazardous waste treatment centers. It can be seen from the table that Yancheng City scored the highest and ranked first, that is, taking into account factors such as population density, hazardous waste generation in recent years, transportation distance, and the number of existing hazardous waste disposal units, among the cities considered in Jiangsu Province, Yancheng City is the best place to establish a hazardous waste treatment center.

Table 2: Total points and ranking of cities

$f(x)$	**urban population density**		**hazardous waste**		**transport distance**		**Number ofhazardous waste disposal units**			
weight λ	**8**		**6**		**4**		**2**			
city	class	poinst	class	points	class	points	class	points	total points $F(x)$	ranking
Yancheng	A=4	32	O=1	6	E=3	12	E=3	6	56	1
Huaian	A=4	32	U=0	0	E=3	12	A=4	8	52	2
Suqian	E=3	24	O=1	6	I=2	8	A=4	8	46	4
Lianyungang	E=3	24	U=0	0	O=1	4	A=4	8	36	6
Yangzhou	I=2	16	O=1	6	A=4	16	A=4	8	46	4
Nantong	I=2	16	E=3	18	E=3	12	I=2	4	50	3
Xuzhou	O=1	8	A=4	24	U=0	0	A=4	8	40	5
Taizhou	U=0	0	O=1	6	A=4	16	I=2	4	26	8
Zhenjiang	U=0	0	O=1	6	A=4	16	A=4	8	30	7
Changzhou	U=0	0	O=1	6	A=4	16	U=0	0	22	9

It is mentioned in the regional hazardous waste analysis of "Changjiang Securities" that Yancheng, as a major chemical market for pesticides and other chemicals, may have underestimated the production of hazardous waste. Therefore, the establishment of a hazardous waste treatment center in Yancheng will not only benefit the province’s hazardous waste treatment work. Significant help also has potential significance for its own hazardous waste treatment industry. In 2019, the overall soil environmental quality in Yancheng City remained safe and stable. There were no soil environmental pollution incidents. The air quality also ranked first in the province. It can be seen that Yancheng City has the absolute conditions and strength to contribute to the hazardous waste treatment work in Jiangsu Province.

3. Conclusions and suggestions

The study found: During the sample inspection period, the production of hazardous waste in China's provincial administrative regions has a tendency to shift from the western region to the eastern coastal region. The high output and low distribution of hazardous waste production shows randomness. From a global perspective, the spatial distribution of hazardous waste production in China's provinces is very weak, which also explains the randomness of the high output and low spatial distribution of hazardous waste production in various provinces in China. Yancheng City is the proposed best location. Taking into

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account factors such as population density, hazardous waste generation in recent years, transportation distance, and the number of existing hazardous waste disposal units, Yancheng City, Jiangsu Province has superior conditions for hazardous waste treatment.

Combined with the analysis of this article, the following suggestions are put forward: Relevant departments should attach great importance to the social problem of the general increase in the production of hazardous waste in various provinces in our country, and conduct targeted research and formulate corresponding hazardous waste management to solve it. It is suggested that when formulating hazardous waste management and control measures in various provinces, relevant departments should fully consider regional differences, combine regional characteristics such as geography and social development in a targeted manner, and solve the problem of the emergence of hazardous waste production from a practical perspective.

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