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# Influence Factors Analysis and Generation Prediction of Beijing Municipal Solid Waste

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Abstract: This paper analyzes 23 selected indicators of influencing the generation of Beijing municipal solid waste by adopting principal component analysis, and finally divides the factors into 3 principal components, i.e. urban development degree, price index indicator and liquefied petroleum gas sales volume. The paper calculates the correlation among various indicators and Beijing municipal solid waste generation through the calculation of correlation coefficient, and classifies various indicators into three types, i.e. high linear correlation, significant correlation and low linear correlation. In addition, this paper also conducts multivariate regression analysis to various indicators through statistical software after dimensionless method and finally obtains the multivariate regression equation of Beijing municipal solid waste generation, and verifies the multivariate regression equation with absolute error, relative error, and goodness-of-fit, etc, indicating that this equation has a high goodness-of-fit and can be used for predicting Beijing municipal solid waste generation.

Keywords: Beijing, solid waste, influence factor, generation, prediction

## 1 Introduction

With the acceleration of urbanization process and the improvement of living standard, the municipal solid waste presents a fast growing trend in quantity, which becomes an important problem of polluting the environment and affecting urban sustainable development, and also receives more and more concerns [1]. The influence factors of municipal solid waste generation are complex and changeful, and the change is the result of combined action of influence factors, and the ways and degrees of various influence factors are different [2]. The scientific and accurate prediction of municipal solid waste generation and the analysis of its influence factors can provide scientific basis for implementing scientific and effective urban environment management and the future development planning of urban, which is an important foundational work to manage the municipal solid waste [3]. As the capital of our country, the problem of domestic waste in Beijing is prominent. The analysis of component of Beijing municipal solid waste, the discussion on the influence factors of Beijing municipal solid waste generation and the prediction of Beijing municipal solid waste generation for years to come will provide important basis for the project construction, the collection and transportation, disposal, development planning and urban development planning of Beijing municipal solid waste, which is the valuable data of urban construction and management.

## 2 Beijing municipal solid waste component and the change trend of its generation

Generally, the solid waste can be defined as solid and self-solid waste which are discarded or generated in daily life, work or production such as household waste, road sweeping waste, commercial waste, waste from unit and organization and transport waste, etc. [4]. By physical components, the municipal solid waste in China can be classified into kitchen organics, paper, plastic rubber, glass, metal, wood and bamboo, dust, tile and brick, and ceramics, etc [5],please refer to Tab.1.

In the field of domestic waste generation, the solid waste of Beijing increases to 6,728,200 ton in 2008 from 4,954,600 ton in 2004, with the average annual growth rate of 6.31%. Since 2008 Beijing Olympic Games, the

**Tab.1 Physical components of municipal solid waste**

| Recoverable matters | | | | | | Inorganic matters | | Kitchen organic matters | |
|---|---|---|---|---|---|---|---|---|---|
| paper | Plastic, rubber | Textile fabrics | Glass | Metal | Wood and bamboo | Dust | Brick and tile, ceramics | Animal | Plant |



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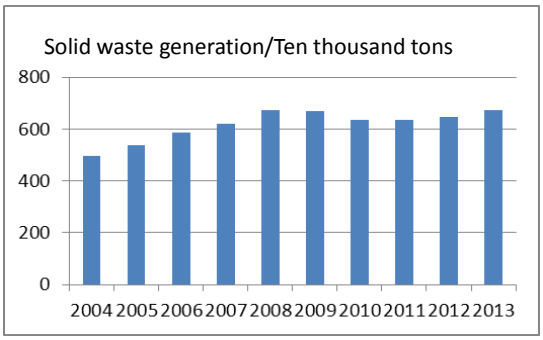


**Fig.1 Change chart of Beijing municipal solid waste generation**

increase of environment protection intensity and a series of measures for waste reduction partly restrain the growth of waste generation, and the waste generation presents a negative growth from 2009 to 2011. By 2011, Beijing municipal solid waste generation is 6,343,500 ton. However, the waste generation between 2011 and 2013 presents a rising trend again, please refer to Fig.1.

## 3 Influence factors analysis of municipal solid waste

In our country, there are many factors of influencing municipal solid waste generation and component, which can be classified into 4 types [6]: 1. internal factor, it refers to the factor which can directly cause the change of the generation and component, such as population, urban economic development, living standard and urban construction level, etc [7-8]; 2. Natural factor, it refers to the influence of region, season, such as geographical location and climate, etc [9-10]; 3. Individual factor, it mainly refers to individual behavior, living style, education level, etc. of waste generation [11-12]; 4. social factor, it refers to social behavior standard, rules and regulations, etc, an external factor of restricting internal factor and individual behavior, which externally influences the generation and component of municipal solid waste through resource recovery, reduction, etc [13]. In the four types of influence factors, the internal factor holds a dominant position. As a rule, the larger the urban size, the more the population, and the more the domestic waste generated. In addition, the improvement of living standard and the change of urban energy structure significantly influence the component and generation of domestic waste. The natural factor is an external factor, reflected in the influence of natural environment and seasonal change on the generation and component of domestic waste, and the influence degree is related to urban energy structure and other internal factors. The influence of individual factor and social factor are mainly reflected in waste reduction, recovery, recycling, and other measures and regulations. The individual factor and social factor are the main control factors to regulate and control the municipal solid waste.

## 4 Generation prediction of Beijing municipal solid waste

### 4.1 Principle and method

The generation of municipal solid waste is influenced by many factors; multi-index evaluation will not only increase the workload, but also lower the function of main indicators. For this, some primary and typical indicators should be selected from several indicators. However, the considered indicators inevitably have subjectivity, causing the loss of valuable information and producing large error and mistake. Therefore, it is necessary to process the considered indicators with mathematical method to make them become a few mutually independent aggregative indicators, and then further analyze the main influence factors of the generation of solid waste according to these indicators. Principal component analysis is an objective multivariate statistical method, which provides a very effective mathematical method for achieving this thinking. The determination of closeness degree of correlation among various influence factors is completed mainly through the calculation and inspection of correlation analysis and regression analysis to correlation data and regression equation.

The principal component analysis can be researched on the basis of original data or standardized data, namely sample covariance matrix or sample correlation matrix[11-15].

The correlation analysis to data and influence factors aims at resolving the following problems in proper order [15-26]:

The determination of correlation coefficient: The correlation coefficient is a value of representing linear correlation degree among variables. larger the correlation coefficient, the higher the linear correlation degree; the less the correlation coefficient, the lower the linear correlation degree among variables. For factor x, y, if the sample values are respectively $x_i$, $y_i$ (i=1,2,...,n), the correlation coefficient is

$$r_{xy}=\frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} \quad (1)$$

In the above formula, $\bar{x}$ and $\bar{y}$ respectively denote the average values of two factor sample values, namely

$$\bar{x}=\frac{1}{n}\sum_{i=1}^{n}x_i,\ \bar{y}=\frac{1}{n}\sum_{i=1}^{n}y_i \quad (2)$$

$r_{xy}$ is the value of correlation coefficient between x and y, with the value within [-1,1]. $r_{xy}$>0 is positive

**Tab.2 Generation and relevant indicator data of Beijing municipal solid waste**

| Year | Solid waste generation/ten thousand tons | Permanent population/ten thousand person | Gross regional production/100 million Yuan | Per capita gross regional production /Yuan | Urban per capita household income /Yuan | Urban per capita disposable income /Yuan | Urban per capita nonproductive expenditure /Yuan | Urban per capita housing construction area /m2 | Resident consumption level/ Yuan | Total Electricity Consumption/ten thousand kWh | Year-end park greenbelt/hectare | Per capita park greenbelt /m2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 |
| 2004 | 495.46 | 1492.7 | 6033.2 | 40916 | 17116.5 | 15637.8 | 12200.4 | 21.49 | 13425 | 5131804 | 10446 | 11.45 |
| 2005 | 536.93 | 1538 | 6969.5 | 45993 | 19533.3 | 17653 | 13244.2 | 22.03 | 14662 | 5705364 | 11365 | 12 |
| 2006 | 585.13 | 1601 | 8117.8 | 51722 | 22417 | 19978 | 14825 | 23.65 | 16487 | 6115719 | 11788 | 12 |
| 2007 | 619.49 | 1676 | 9846.8 | 60096 | 24576 | 21989 | 15330 | 24.77 | 18553 | 6670089 | 12101 | 12.6 |
| 2008 | 672.82 | 1771 | 11115 | 64491 | 27678 | 24725 | 16460 | 26.9 | 20113 | 6897189 | 12316 | 13.6 |
| 2009 | 669.13 | 1860 | 12153 | 66940 | 30674 | 26738 | 17893 | 27.69 | 22023 | 7391465 | 18070 | 14.5 |
| 2010 | 634.86 | 1961.9 | 14114 | 73856 | 33360 | 29073 | 19934 | 28.94 | 24982 | 8099029 | 19020 | 15 |
| 2011 | 634.35 | 2018.6 | 16252 | 81658 | 37124 | 32903 | 21984 | 29.38 | 27760 | 8217055 | 19728 | 15.3 |
| 2012 | 648.31 | 2069.3 | 17879 | 87475 | 41103 | 36469 | 24046 | 29.26 | 30350 | 8742835 | 21178 | 15.5 |
| 2013 | 671.69 | 2114.8 | 19501 | 93213 | 45274 | 40321 | 26275 | 31.31 | 33337 | 9131113 | 22215 | 15.7 |

| Year | Public transport commercial vehicle/vehicle | public transport passenger capacity /ten thousand passenger | Consumer price index | Producer price index | Fixed asset investment price index | Central heating area/ten thousand m2 | Quantity of tourists to Beijing/ten thousand person | Total Retail Sales of consumer goods/100 million Yuan | Commercial housing construction area/ten thousand m2 | Liquefied petroleum gas sales volume/ ton | Natural gas sales volume/ ten thousand m3 | total import and export value/ten thousand dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | X12 | X13 | X14 | X15 | X16 | X17 | X18 | X19 | X20 | X21 | X22 | X23 |
| 2004 | 19343 | 499830 | 101 | 103 | 104.3 | 28150 | 12265.5 | 2626.6 | 9931.3 | 431660 | 250326 | 9457572 |
| 2005 | 19471 | 517769 | 101.5 | 101.3 | 100.7 | 31736 | 12862.9 | 2911.7 | 10748.5 | 356551 | 294279 | 12550643 |
| 2006 | 20489 | 468225 | 100.9 | 99.1 | 100.4 | 34977 | 13590.3 | 3295.3 | 10483.5 | 415268 | 389202 | 15803663 |
| 2007 | 20525 | 488138 | 102.4 | 99.7 | 102.8 | 37203 | 14715.5 | 3835.2 | 10438.6 | 319631 | 441327 | 19299976 |
| 2008 | 23221 | 592523 | 105.1 | 103.3 | 107.8 | 42501 | 14560 | 4645.5 | 10014.3 | 289576 | 578626 | 27169290 |
| 2009 | 23730 | 658785 | 98.5 | 94.4 | 97.1 | 44240 | 16669.5 | 5309.9 | 9719.1 | 332693 | 645356 | 21479103 |
| 2010 | 24011 | 689788 | 102.4 | 102.2 | 102.5 | 46715 | 18390.1 | 6229.3 | 10300.9 | 299392 | 677009 | 30166129 |
| 2011 | 24478 | 722552 | 105.6 | 102.3 | 105.7 | 50794 | 21404.4 | 6900.3 | 12065.4 | 394437 | 726229 | 38958314 |
| 2012 | 25831 | 761578 | 103.3 | 98.4 | 101.3 | 52555 | 23134.6 | 7702.8 | 13122.5 | 379371 | 883385 | 40810735 |
| 2013 | 27590 | 804775 | 103.3 | 97.4 | 99.9 | 54591 | 25189 | 8375.1 | 13886.9 | 453546 | 956852 | 42994169 |

correlation, and $r_{xy}$ <0 is negative correlation. The closer to 1 of the absolute value of $r_{xy}$, the closer the relation between the two factors; the closer to 0, the less the relation. It can be generally divided by three levels: $|r_{xy}|$ <0.4 is low linear correlation; $0.4 \le |r_{xy}|$ <0.8 is significant correlation; $0.8 \le |r_{xy}|$ <1 is high linear correlation.

Inspect the confirmed correlation coefficient. Correlation coefficient is an important indicator of measuring the linear correlation degree among variables, and the significance test should be carried out to determine whether the size of this value is statistically significant. In mathematical statistics, the correlation test of correlation coefficient is mainly achieved through t-test and the difference test of sample correlation coefficient and total correlation coefficient. Under the hypothesis condition of total correlation coefficient of 0, the correlation coefficient follows t distribution with the

**Tab.3 Characteristic value and cumulative contribution rate**

| | Initial characteristic value | | | Extraction quadratic sum load | | | Rotation quadratic sum load | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Total | Variance % | Accumulation % | Total | Variance % | Accumulation % | Total | Variance % | Accumulation % |
| 1 | 18.496 | 80.417 | 80.417 | 18.496 | 80.417 | 80.417 | 18.161 | 78.959 | 78.959 |
| 2 | 2.587 | 11.250 | 91.666 | 2.587 | 11.250 | 91.666 | 2.561 | 11.137 | 90.096 |
| 3 | 1.348 | 5.860 | 97.527 | 1.348 | 5.860 | 97.527 | 1.709 | 7.431 | 97.527 |
| 4 | 0.269 | 1.168 | 98.694 | | | | | | |
| 5 | 0.162 | 0.706 | 99.400 | | | | | | |
| 6 | 0.063 | 0.275 | 99.675 | | | | | | |
| 7 | 0.039 | 0.171 | 99.846 | | | | | | |
| 8 | 0.027 | 0.118 | 99.964 | | | | | | |
| 9 | 0.008 | 0.036 | 100.000 | | | | | | |
| 10 | 1.128E-15 | 4.904E-15 | 100.000 | | | | | | |
| 11 | 5.563E-16 | 2.419E-15 | 100.000 | | | | | | |
| 12 | 3.976E-16 | 1.729E-15 | 100.000 | | | | | | |
| 13 | 3.576E-16 | 1.555E-15 | 100.000 | | | | | | |
| 14 | 2.854E-16 | 1.241E-15 | 100.000 | | | | | | |
| 15 | 2.071E-16 | 9.004E-16 | 100.000 | | | | | | |
| 16 | 8.521E-17 | 3.705E-16 | 100.000 | | | | | | |
| 17 | 2.515E-17 | 1.093E-16 | 100.000 | | | | | | |
| 18 | -3.081E-18 | -1.340E-17 | 100.000 | | | | | | |
| 19 | -1.532E-16 | -6.660E-16 | 100.000 | | | | | | |
| 20 | -2.891E-16 | -1.257E-15 | 100.000 | | | | | | |
| 21 | -3.389E-16 | -1.474E-15 | 100.000 | | | | | | |
| 22 | -4.016E-16 | -1.746E-15 | 100.000 | | | | | | |
| 23 | -7.151E-16 | -3.109E-15 | 100.000 | | | | | | |

Extraction method: principal component analysis

freedom of n-2. When t> $t_a$, it is considered that the correlation coefficient is significant.

Determination of regression model: firstly, suppose that the relation among many factors and variables is linear correlation. Next, establish regression model between factors and variables through multivariate statistical software. Confirm coefficient $a$ through least square method to obtain multivariate regression equation.

Significance test of regression equation: in order to confirm whether the obtained regression equation is accidental or has statistic significance, it is necessary to test the regression equation.

$R^2$ is goodness-of-fit coefficient, the ratio of regression sum of squares and total dispersion square sum, denoting the percentage of linear variance of many factors and variables, with the value of $0 \le R^2 \le 1$. Use goodness-of-fit coefficient to conduct significance test to the equation. At significance level $a$, if $F < F_a$, the hypothesis that the total correlation coefficient is 0 should be affirmed, namely that regression equation is significant.

The above data analysis and calculating process are conducted by using SPSS17.0 statistical software [27-29].

### 4.2 Selection of principal component factor indicator

On the basis of the thinking and basic requirements of principal component analysis, following the principles such as scientificity, systematicness, dynamics, feasibility, data acquisition, and considering the actual condition of Beijing, we select the urban development degree, living standard, industrialization level and total urban economy strength, etc. 23 factors related to Beijing municipal solid waste generation as independent variable group X, and select the generation of Beijing solid waste as independent variable group Y. For the specific data of various factors, see Tab.2. With 2004-2013 as the scope, the data comes from Beijing statistical yearbook [30].

### 4.3 Principal component analysis

Analyze the original data in SPSS17.0 statistical software.

In view of the different units of selected influences factors, in order to eliminate the error and standardize the data, and then use the obtained correlation matrix to conduct principal component analysis to the influence factors of Beijing municipal solid waste generation to obtain characteristic value and cumulative contribution rate, please refer to Tab.3. In Tab.3, based on the principle that Kaiser selected characteristic value is

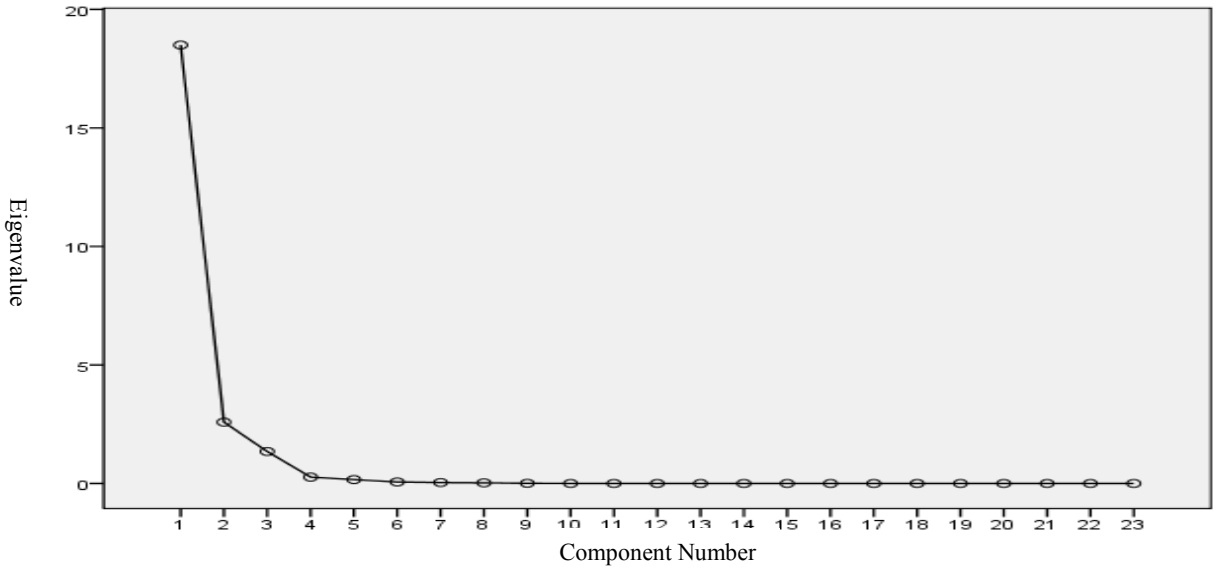


**Fig.2 Scree plot**

greater than 1, it can be known that the characteristic values of 3 principal components are greater than 1, and the cumulative contribution rates are close to 100%, meeting the analysis requirement. Therefore, many factors influencing the generation of Beijing municipal solid waste can be preliminary generalized into 3 principal components. At the same time, analyze the factor scree plot, see Fig.2. On the basis of the gradient degree of the line among various points, the steep line indicates that the difference value of characteristic value of factor corresponding to line breakpoint is large, and the flat line corresponds to the small difference value of characteristic value. From Fig. 2 we can see that the gradient of the line between the fourth factors is relatively steep, thus the difference value of characteristic value is large; while the gradient of line within fourth factor-30$^{th}$ factor is relatively flat, and as a result, the difference value of characteristic value of them is very small. This also certifies that 3 principal components can be extracted from 23 factors of influencing the generation of Beijing municipal solid waste to generalize most information.

From Tab.3 we can obtain the characteristic values of 3 extracted principal components to further get the load matrix of influence factors. Through varimax orthogonal rotation, minimize the variables with highest load on various factors to make the determination of public factor clearer. Use Varimax to conduct maximum rotation to initial factor load matrix, and then list the factor rotation information, see Tab.4. The rotated factor load matrix can better interpret various principal factors.

Tab.4 indicates that the influence factors of Beijing municipal solid waste generation can be divided in to 3 types.

The first type of factor is complex, including permanent population, gross regional production, urban per capita household income, urban per capita housing construction area, resident consumption level, total electricity consumption, year-end park greenbelt, public transport commercial vehicle, total central heating area, quantity of tourists to Beijing, total retail sales of consumer goods, gas sales volume, total import and export value, etc. The above factors are the important indicator of showing the development degree of a city. Under normal conditions, the increase of urban permanent population will cause the increase of solid waste generation. Gross regional production and total import and export value can reflect the economic development level of a city, and urban per capita household income and resident consumption level can directly reflect the living standard. The quantity and types of consumer goods may increase due to the development of economy and the improvement of living standard, correspondingly the solid waste generation will increase. Year-end park greenbelt, public transport commercial vehicle and other factors can reflect the development degree of urban public utilities, and the urban public utilities development degree can partly affect the behavior and living style of resident, and also influence the solid waste generation. While the urban per capita housing construction area and total retail sales of consumer goods can directly reflect the behavior and living style of resident, and also affect the municipal solid waste generation. Total central heating area, natural gas sales volume, total electricity consumption can reflect the energy consumption. The increase of central heating area, natural gas and electricity consumption can substitute for wood, coal, and other traditional energies to reduce the generation of lime-ash and other solid wastes. The increase of quantity of tourists to Beijing will also cause the increase of municipal solid waste generation.

The second type of factor covers consumer price index, producer price index, fixed asset price index.

These indexes can reflect the living standard and consumption habit, thus they will also affect the municipal solid waste generation.

The third type of factor is liquefied petroleum gas sales volume. In general, the community in which the liquefied petroleum is sold most is constructed early, and the resident behavior and habit, living style are different, thus it will affect the municipal solid waste generation.

### 4.4 Determination of correlation coefficient

Select permanent population, gross regional production, and resident consumption level, etc. 23 factors related to municipal solid waste generation as independent variable group X, with Beijing municipal solid waste generation as dependent variable Y, and for specific index of each factor, see Tab.2. With 2004-2013 as the scope, the data comes from Beijing statistical yearbook.

Firstly, on the basis of Beijing municipal solid waste generation Y and the linear regression model of 23 factors, and using SPSS17.0 statistical software to conduct correlation analysis, we can obtain that Pearson correlation coefficient is as shown in Tab.5.

From Tab.5 we can see that in many selected indicators of affecting Beijing municipal solid waste generation, most indicators highly correlate to Beijing municipal solid waste generation. Of which, gross regional production X3, per capita housing construction area X7, total electricity consumption X9, per capita park greenbelt X11, public transport commercial vehicle X12, total central heating area X17 and natural gas sales volume X22 are high linear correlation, i.e. $0.8 \le |r_{xy}| < 1$; permanent population X1, total regional production X2, urban per capita household income X4, urban per capita disposable income X5, urban per capita nonproductive expenditure X6, resident consumption level X8, year-end park greenbelt X10, public transport passenger capacity X13, producer price index X15, quantity of tourist to Beijing X18, total retail sales of consumer goods X19 and total import and export value X23 are significant correlation, i.e. $0.4 \le |r_{xy}| < 0.8$. Only consumer price index X14, fixed asset investment price index X16, commercial building construction area X20 and liquefied petroleum gas sale X21 are low linear correlation, i.e. $|r_{xy}| < 0.4$.

### 4.5 Regression equation and its significance test

Conduct regression analysis to the influence factors of Beijing municipal solid waste generation after dimensionless method, finally obtain the regression equation.

$$y = e^{-0.561514 \ln x_{19} + 0.709761 \ln x_{22} + 1.817267}$$

Of which, $Y$ represents the generation of Beijing municipal solid waste (ten thousand ton), X19 represents total retail sales of consumer goods (100 million Yuan), and X22 represents natural gas sales (ten thousand m3).

**Tab.4 Rotated factor load matrix**

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Permanent population X1 | 0.997 | -0.008 | 0.022 |
| Gross regional production X2 | 0.989 | 0.010 | 0.144 |
| Per capita gross regional productionX3 | 0.992 | 0.018 | 0.091 |
| Urban per capita household income X4 | 0.987 | -0.037 | 0.151 |
| Urban per capita disposable income X5 | 0.983 | -0.022 | 0.177 |
| Urban per capita nonproductive expenditure X6 | 0.973 | -0.027 | 0.224 |
| Urban per capita housing construction area X7 | 0.988 | -0.003 | -0.060 |
| Resident consumption level X8 | 0.984 | -0.010 | 0.174 |
| Total electricity consumption X9 | 0.994 | -0.040 | 0.031 |
| Year-end park greenbelt X10 | 0.954 | -0.180 | 0.118 |
| Per capita park greenbelt X11 | 0.989 | -0.030 | -0.063 |
| Public transport commercial vehicle X12 | 0.978 | -0.046 | 0.079 |
| Public transport passenger capacity X13 | 0.957 | -0.032 | 0.113 |
| Consumer price indexX14 | 0.454 | 0.859 | 0.092 |
| Producer price index X15 | -0.325 | 0.892 | -0.063 |
| Fixed asset price index X16 | -0.086 | 0.964 | -0.137 |
| Total central heating area X17 | 0.996 | 0.009 | 0.015 |
| Quantity of tourists to Beijing X18 | 0.949 | -0.027 | 0.303 |
| Total retail sales of consumer goods X19 | 0.989 | -0.008 | 0.136 |
| Commercial building construction area X20 | 0.715 | 0.055 | 0.640 |
| Liquefied petroleum gas sales volume X21 | 0.009 | -0.130 | 0.964 |
| Gas sales volumeX22 | 0.990 | -0.061 | 0.072 |
| Total import and export value X23 | 0.971 | 0.180 | 0.138 |

Extraction method: principal component analysis.
Rotation method: varimax rotation with Kaiser standardization.
a. the rotation converges after the 4th iteration.

Conduct error analysis to the obtained regression equation, fit the data of 2004-2013 Beijing municipal solid waste generation with the obtained data calculated through the regression equation to obtain relative error and absolute error, see Tab.6. From Tab.6 we can see that

**Tab.5 Short form for Pearson correlation coefficient**

| Influence factor | Correlation coefficient | Influence factor | Correlation coefficient | Influence factor | Correlation coefficient | Influence factor | Correlation coefficient | Influence factor | Correlation coefficient | Influence factor | Correlation coefficient |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Permanent population X1 | 0.796 | Urban per capita disposable income X5 | 0.76 | Total electricity consumption X9 | 0.808 | Public transport passenger capacity X13 | 0.678 | Total central heating area X17 | 0.836 | Liquefied petroleum sales volume X21 | -0.338 |
| Gross regional production X2 | 0.759 | Urban per capital non-productive expenditure X6 | 0.718 | Year-end park greenbelt X10 | 0.678 | Consumer price index X14 | 0.327 | Quantity of tourists to Beijing X18 | 0.646 | Natural gas sales volume X22 | 0.821 |
| Per capita gross regional production X3 | 0.802 | Urban per capita housing construction area X7 | 0.863 | Per capita park greenbelt X11 | 0.804 | Producer price index X15 | -0.428 | Total retail sales of consumer goods X19 | 0.744 | Total import and export value X23 | 0.75 |
| Urban per capita household income X4 | 0.771 | Resident consumption level X8 | 0.743 | Public transport commercial vehicle X12 | 0.811 | Fixed asset investment price index X16 | -0.07 | Commercial housing construction area X20 | 0.349 | | |

**Tab.6 Table of error between actual value and analog value of Beijing municipal solid waste generation**

| Year | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|
| Actual value/ten thousand ton | 495.46 | 536.93 | 585.13 | 619.49 | 672.82 | 669.13 | 634.86 | 634.35 | 648.31 | 671.69 |
| Analog value/ten thousand ton | 502.16 | 531.59 | 604.74 | 607.17 | 660.79 | 662.38 | 626.51 | 621.75 | 671.69 | 678.24 |
| Absolute error/ten thousand ton | 6.7 | -5.34 | 19.61 | -12.32 | -12.03 | -6.75 | -8.35 | -12.6 | 23.38 | 6.55 |
| Relative error/% | 1.3523 | -0.9945 | 3.3514 | -1.9887 | -1.788 | -1.0088 | -1.3153 | -1.9863 | 3.6063 | 0.9752 |

the error between the actual value of Beijing municipal solid waste generation and the data calculated through regression equation is minor. Of which, the year of maximum relative error is 2012, only 3.6063%. Analyzing the data of 2004-2013, we can obtain that any relative error of each year is less than 4%, indicating the fitting of regression equation is favorable.

Through further verifying the regression equation, we obtain that the goodness-of-fit coefficient $R^2$ is about 0.9567, indicating that the regression equation is significant. By the equation, we can predict that in 2015 Beijing municipal solid waste will be 692.44 ten thousand tons.

In conclusion, the fitting of this regression equation is favorable, which can better predict the generation of Beijing municipal solid waste.

## 5 Conclusions

In this paper, the influence factors of Beijing municipal solid waste generation can be roughly divided into 3 types, i.e. urban development degree, price index indicator and liquefied petroleum sales volume. By using multivariate regression model to predict the generation of Beijing municipal solid waste, we obtain that the generation of Beijing municipal solid waste can be predicted through two factors, i.e. total retail sales of consumer goods and natural gas sales volume, the equation is

$$y = e^{-0.561514\ln x_{19} + 0.709761\ln x_{22} + 1.817267},$$

Of which, Y represents Beijing municipal solid waste generation (ten thousand ton), X19 represents total retail sales of consumer goods (100 million Yuan), and X22 is natural gas sales volume (ten thousand m3). The calculation of absolute error, relative error, goodness-of-fit coefficient shows that the fitting of this regression equation is favorable, which can provide some data with reference value to Beijing environmental management, planning, environment facilities construction. Certainly, the selected indicators are impossible to fully reflect all situations of Beijing municipal solid waste generation because certain subjectivity may exist in the selection of indicator, thus further study should be carried out.

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