Journal of Applied Science and Engineering Innovation, Vol.6, No.4, 2019, pp. 195-202
ISSN (Print): 2331-9062
ISSN (Online): 2331-9070

Research on Comprehensive Evaluation of Air Quality in Beijing Based on Entropy Weight and Grey Clustering Method

Qi Gao, Baosheng Zhang, Zonglin Yang
Department of Economic Management, North China Electric Power University, Baoding, China

Abstract*:* This paper introduces the theory of entropy value in information theory into the calculation of air quality assessment, and calculates the weight coefficient through the information disordered utility value reflected by the data itself, so as to effectively reduce the influence of subjective factors. By introducing the improved grey clustering model with entropy weight, the evaluation method is enriched and improved. It is found that the main influencing factor of air quality in Beijing is the concentration of O3, followed by CO concentration. The influence degree of PM2.5, PM10 and NO2 is close, and the effect of SO2 on air quality in Beijing is not obvious. The air quality in Beijing in the first quarter is generally better than that in the second and third quarter. With the implementation of air pollution prevention and control actions, Beijing's air quality has been gradually optimized.

Keywords Comprehensive evaluation; Entropy weight method; Erey clustering; air quality

INTRODUCTION

In recent years, heavy pollution weather occurs frequently in Beijing, Tianjin, Hebei and surrounding areas in autumn and winter, and the air quality problem has attracted much attention. In 2013, Beijing Tianjin Hebei region suffered from serious haze pollution. This haze caused widespread concern in the society with the characteristics of long duration and wide range of influence. During the period of heavy haze pollution, PM2.5 with high concentration continuously threatened the public health and safety (Liu and Lei , 2018). Under the background of increasingly serious atmospheric environment problems, the State Council issued the action plan for air pollution prevention and control in September 2013, which clearly put forward the requirements for air environment treatment in the next five years. The air quality requirements of Beijing are also put forward in the air pollution prevention and control work plan of Beijing, Tianjin, Hebei and surrounding areas in 2017 formulated by the former Ministry of environmental protection (now the Ministry of ecological environment). The Beijing Tianjin Hebei region government, in combination with its own actual situation, has successively issued relevant air pollution prevention and control action rules and achieved positive results in haze control (Liu et al., 2018). How to effectively prevent and control air pollution has become one of the important research topics (Sun et al., 2019). The accurate evaluation of air quality is of great significance for the objective understanding of the current situation and changing trend of air pollution in cities and the formulation of corresponding pollution control countermeasures.

LITERATURE REVIEW

At present, in the face of worsening air quality, scholars at home and abroad have carried out a lot of relevant research, mainly focusing on the spatial and temporal distribution characteristics of air quality and the analysis of the influencing factors of air quality. The commonly used methods of air quality evaluation are: air pollution index method, grey clustering method, AHP and fuzzy comprehensive evaluation method (Wang and Yue, 2018).

Sun et al. (2017) Used fuzzy comprehensive evaluation and factor analysis to analyze the air quality of 31 major cities including Beijing, Tianjin and Shijiazhuang. Zhang et al. (2017) analyzed the main factors influencing the air quality of Lanzhou City by using the fuzzy comprehensive evaluation method, and found that the air quality of Lanzhou city has obvious seasonal change characteristics. Wang et al. (2016) constructed two comprehensive evaluation indexes of industrial pollution industry concentration and air pollution emission, and studied the pollution distribution characteristics of various regions in China. Xie et al. (2017) aiming at the quantitative collection of haze tax, established the evaluation index system of haze tax influencing factors by using the analytic hierarchy process, evaluated the impact of different industries' production on haze by using the fuzzy comprehensive evaluation method, and determined the collection object of haze tax. (Xu, *et. al.*, 2019) Li built a comprehensive evaluation system of haze governance performance based on DPSIR model, analyzed the temporal and spatial evolution characteristics of haze governance in Beijing Tianjin Hebei Urban Agglomeration during 2004-2016, and found that: during 2004-2016, the effect of haze governance in Beijing and Tianjin was significant (Li, 2019). By combining the entropy method with the attribute recognition model, Liu established the attribute recognition model based on entropy weight to carry out the comprehensive evaluation of air quality, thus avoiding the subjective problem of weight determination (Liu and Zhang., 2008). Li et al.(2019)

Quantitatively evaluated the impact of meteorological conditions and air pollution control measures on air quality in Beijing using multiple linear regression method. Through the analysis of air quality in Beijing, Gao Ming et al.(2017) Concluded that the factors affecting air quality are formed by the interaction of industrial structure, industrial pollution source emissions and meteorological factors . According to the data samples of PM10, SO2 and NO2 in the air of Chengdu, Tao and other scholars used the fuzzy comprehensive evaluation method and the grey correlation analysis method to evaluate the air quality, and determined the main factors affecting the air quality through the classification and qualitative test (Tao *et al.*, 2017).

In this paper, entropy weight method is used to determine the weight of air quality influencing factors in Beijing, and on this basis, the improved grey clustering analysis method is applied to comprehensive evaluation of air quality. The purpose of analyzing the trend of air quality change in Beijing since 2014 is to comprehensively understand the change characteristics of air environment quality and the influence degree of different influence factors on air quality, so as to provide scientific basis for the improvement of urban air quality and the implementation of comprehensive treatment by relevant departments.

THEORETICAL BASIS

Entropy method

Information entropy is a measure of the disorder degree of a system. It is defined as the probability weighted statistical average of information quantity, that is:$H = -\sum_{i=1}^{n} p_i lg p_i$

Where Pi is the probability of the event. Formula (1) shows that h is a function of Pi or P (x), and it is a representation of average uncertainty. The larger the amount of information, the smaller the uncertainty and the smaller the entropy; on the contrary, the smaller the amount of information, the greater the uncertainty and the greater the entropy. This characteristic of information entropy is introduced into the comprehensive evaluation. It can be seen that the greater the difference degree of an indicator, the smaller the information entropy, the greater the weight of the indicator; the smaller the difference degree of an indicator value, the smaller the weight of the indicator (Fu *et al.*, 2007).

Entropy weight method is a method to determine the weight of each index by the judgment matrix composed of the monitoring values of each evaluation index under objective conditions. It refers to the order degree and utility of the system obtained by information entropy evaluation, because it avoids the subjectivity of the weight of each factor as much as possible (Yang et al., 2006), so the evaluation results can better reflect the actual situation.

There are six kinds of pollutants in the air quality evaluation. Because of the different functions of various pollutants, the weight of various pollutants should be different in the evaluation process. Therefore, six kinds of pollutants should be given different weights according to their functions. The principle of weight determination is that the greater the effect of pollutants, the greater the weight of the indicator. The effect of the indicator can be measured according to its entropy value. Therefore, entropy method will be used to determine the weight of each pollutant (Yu *et al.*, 2018).

Basic principle of Grey Clustering

In general, a collection of observations of the same type can be used as a cluster. Grey clustering is to use grey correlation matrix or grey quantity whitening weight function to classify the detection objects. The interval value of the level index value in the cluster is reflected by establishing the whitening weight function of the target index (Ma et al., 2013). The urban air quality evaluation model proposed in this paper is to improve the clustering method of grey whitening weight in the application scope of grey clustering. The overall idea of grey clustering is to build the whitening weight function to transform grey information, and the weight of various indicators in the information is taken into account in the transformation process (He et al., 2019).

ESTABLISHMENT OF COMPREHENSIVE EVALUATION MODEL OF AIR QUALITY IN BEIJING

In order to analyze the air quality of Beijing, this paper uses entropy weight method to determine the weight of the influencing factors of air quality of Beijing, and on this basis, the improved grey clustering analysis method is applied to evaluate the air quality comprehensively.

Data source

Combined with the national ambient air quality standard (GB3095-2012), it is determined that fine particles (PM2.5), inhalable particles (PM10), sulfur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2) and ozone (O3) are used as the air quality evaluation factors, which is the clustering index of grey clustering. The monthly statistical historical data of air quality index of Beijing from January 2014 to March 2019 are processed to obtain the air quality data by quarter from 2014 to 2019, as shown in Table 1.

Table 1 air quality data of Beijing from the first quarter of 2014 to the first quarter of 2019

(value unit: μ g / m3)

Time	PM2.5	PM10	SO_2	CO	NO_2	O_3
The first quarter of 2014	112	139	47	1836	65	54
The second quarter of 2014	68	112	12	852	48	149
The third quarter of 2014	72	92	6	920	44	149
The fourth quarter of 2014	87	123	18	1486	63	44
The first quarter of 2015	92	127	27	1520	57	62
The second quarter of 2015	62	95	8	936	38	144
The third quarter of 2015	52	66	4	817	36	148
The fourth quarter of 2015	115	114	13	1934	64	42
The first quarter of 2016	68	94	18	1239	48	63
The second quarter of 2016	61	93	8	745	39	153
The third quarter of 2016	57	69	3	836	37	133
The fourth quarter of 2016	106	131	11	1821	68	34
The first quarter of 2017	83	100	16	1478	56	64
The second quarter of 2017	48	94	7	717	41	149
The third quarter of 2017	49	76	3	870	39	143
The fourth quarter of 2017	49	68	5	972	48	39
The first quarter of 2018	56	81	9	926	45	72
The second quarter of 2018	53	94	5	749	39	151
The third quarter of 2018	38	50	3	797	29	128
The fourth quarter of 2018	51	80	6	896	50	49
The first quarter of 2019	52	77	7	813	41	65

Determination of weight of air quality comprehensive evaluation index

There are six kinds of pollutants in the air quality evaluation. Because of the different functions of various pollutants, the weight of various pollutants should be different in the evaluation process. Therefore, six kinds of pollutants should be given different weights according to their functions. The principle of determining the weight is that the greater the effect of pollutants, the greater the weight of the index. The effect of the index can be measured according to its entropy value. (Xu, 2018) Therefore, this paper uses entropy method to determine the weight of each pollutant. In order to determine the weight, m evaluation indexes and n groups of data are set, thus forming the original index data x_{ij} $(i = 1,2,\dots,n; j = 1,2,\dots,m)$ The steps of using entropy method to determine index weight are as follows.

First, the index is dimensionless. Because the meaning and measurement unit of each evaluation index are different, and the magnitude is different, in order to facilitate statistical comparison, before comprehensive evaluation, it is necessary to remove the dimensional differences between different indexes and the impact of individual extreme values on the evaluation results, standardize these indexes, and make them fall into a dimensionless interval.

For a positive indicator, that is, the larger the indicator value, the better the indicator is, the dimensionless processing formula for the indicator is:

$$x'_{ij} = \frac{x_{ij} - minx_{ij}}{maxx_{ij} - minx_{ij}} \ (i = 1,2,\dots,n; j = 1,2,\dots,m) \quad (1)$$

For the inverse index, i.e. the smaller the index, the better the index, the dimensionless processing formula of the index is as follows:

$$x'_{ij} = \frac{maxx_{ij} - x_{ij}}{maxx_{ij} - minx_{ij}} \ (i = 1,2,\dots,n; j = 1,2,\dots,m) \quad (2)$$

The air quality data in this paper are all inverse indexes, so the dimensionless processing method of formula 2 is adopted.

On this basis, the normalized matrix is obtained x'_{ij} $(i = 1,2,\dots,n; j = 1,2,\dots,m)$.

Calculate the proportion or probability of data after dimensionless processing, Pij. Calculate the proportion or probability of the i-th data of the j-th index after dimensionless processing, and the formula is as follows:

$$P_{ij} = x'_{ij} \Big/ \sum_{i=1}^{n} x'_{ij} \quad (i = 1,2,\dots,n; j = 1,2,\dots,m) \quad (3)$$

Calculate the entropy value ej of index j. The calculation formula of entropy value of index j is:

$$e_j = -\frac{1}{lnn}\sum_{i=1}^{n} P_{ij} lnP_{ij} \quad (j = 1,2,\dots,m) \qquad (4)$$

Among them, ln is the natural logarithm, and ej ≥ 0. In order to make lnP_{ij} meaningful, it is generally assumed that when $P_{ij} = 0$, $P_{ij}lnP_{ij} = 0$. However, when $P_{ij} = 1$, $P_{ij}lnP_{ij}$ is also equal to zero, which is obviously not practical and contrary to the meaning of entropy. Therefore, P_{ij} needs to be modified (Yao et al., 2017), which is defined as:

$$P_{ij} = (1 + x'_{ij}) \Big/ \sum_{i=1}^{n}(1 + x'_{ij}) \quad (i = 1,2,\dots,n; j = 1,2,\dots,m) \qquad (3-2)$$

Calculate the difference coefficient c_j of index j. The coefficient of difference is defined as:

$$c_j = 1 - e_j \qquad (5)$$

When c_j is larger, the index is more important.

Finally, calculate the weight of index j. The weight formula of item j is:

$$w_j = c_j \Big/ \sum_{j=1}^{m} c_j \quad (j = 1,2,\dots,m) \qquad (6)$$

Comprehensive assessment process of air quality in Beijing

At present, there are many deficiencies in the calculation method of air quality index in China. Therefore, a new evaluation system is adopted in this paper. In fact, a pollutant index belongs to a certain category with fuzziness. Therefore, this paper uses the improved grey clustering analysis method to evaluate the air quality comprehensively, (Song, et. al., 2017) so that the evaluation results are more accurate and objective. The specific steps are as follows.

Determine the limit values of various pollutant groups at different levels

First, the limit values of six pollutants in the first, second, third, fourth, fifth and sixth levels are determined. The division standard is mainly based on the relevant literature and standards. The group spacing of the first and second categories of pollutants is appropriately reduced according to the past standards, while the group spacing of other levels is unchanged. Each pollutant is divided into 12 sections within its measurement range, among which the lower and upper limits of the first to sixth categories of ash are respectively: $x_i^1 \sim x_i^4, x_i^2 \sim x_i^6, x_i^4 \sim x_i^8, x_i^6 \sim x_i^{10}, x_i^8 \sim x_i^{12}, x_i^{10} \sim x_i^{13}$.

See Table 2 for specific segment standards.

Table 2 pollutant corresponding to different categories interval (microgram / m3)

	PM2.5	PM10	SO2	CO	NO2	O3
x_i^1	0	0	0	0	0	0
x_i^2	20	37.5	25	2500	25	50
x_i^3	40	75	50	5000	50	100
x_i^4	60	112.5	75	7500	75	150
x_i^5	80	150	100	10000	100	200
x_i^6	115	200	350	15000	200	300
x_i^7	150	250	600	20000	300	400
x_i^8	185	300	850	25000	400	500
x_i^9	220	350	1100	30000	500	600
x_i^{10}	255	400	1350	35000	600	700
x_i^{11}	290	450	1600	40000	700	800
x_i^{12}	325	500	1850	45000	800	900
x_i^{13}	360	550	2100	50000	900	1000

Calculation of membership

In the grey clustering analysis, the grey whitening weight function is generally calculated, which is to calculate the pollutant index belonging to a certain grey function value. Based on the gray-scale whitening function of the evaluation index, the gray-scale whitening value is obtained, where x is the actual index in the whitening number. An actual value xi of the i-th pollutant index belongs to class k membership degree, which is determined by the following formula.

When $x_i \le x_i^2$:

$$f_i^1(x_i) = 1, f_i^2(x_i) = 1 - f_i^1(x_i) \qquad (7)$$

When $x_i > x_i^{12}$:

$$f_i^6(x_i) = 1, f_i^5(x_i) = 1 - f_i^6(x_i) \qquad (8)$$

When $x_i^{2k} < x_i \le x_i^{2(k+1)}$ $(k = 1,2,\dots,5)$:

$$f_i^{k+1}(x_i) = \frac{x_i - x_i^{2k}}{x_i^{2(k+1)} - x_i^{2k}}, f_i^k(x_i) = 1 - f_i^{k+1}(x_i) \qquad (9)$$

Among them, $f_i^k(x_i)$ is the subordination function of the i-th pollutant, k is the category of pollutant, and x_i is the concentration of the i-th pollutant.

The calculated pollutant data belong to the weighted membership degree of different pollution levels. In order to carry out the comprehensive evaluation of air quality, we should multiply the membership degrees belonging to different levels of different pollutants by their respective weights to obtain that the data of air pollutants belong to the weighted membership degrees of different pollution levels. The calculation formula is as follows:

$$z_i^k = f_i^k(x) \times w_i \quad (k = 1,2,3,\dots,6) \qquad (10)$$

Among them, z_i^k is the weighted membership degree of the ith pollutant, and w_i is the weight of the ith pollutant.

Calculate the membership degree of different pollution levels in the area. In order to carry out comprehensive evaluation, the membership degrees of different pollutants of the same level are added to get the membership degrees of different pollution levels in the evaluation area. The calculation formula is as follows:

$$p^k = \sum_{i=1}^{6} z_i^k \quad (k = 1,2,3,\dots,6) \qquad (11)$$

Where: p^k is the subordination degree of k pollution level for all air.

Comprehensive evaluation

In order to further evaluate, give different scores to different levels, 95 scores, 85 scores, 75 scores, 65 scores, 55 scores and 45 scores to air quality level 1-6 respectively, multiply the scores of different levels by the membership degree of corresponding levels, and add the scores of different levels in the same year to get the total score.

EVALUATION RESULTS AND ANALYSIS

According to the pollutant data of Beijing in Table 1, the entropy value, difference coefficient and index weight of various pollutants can be calculated by formula (1) to formula (6). See Table 3 for the specific calculation results.

Table 3 entropy value, difference coefficient and index weight of various pollutants in Beijing

	PM2.5	PM10	SO_2	CO	NO_2	O_3
Entropy	0.994465	0.995044	0.997104	0.993501	0.994493	0.988123
Coefficient of difference	0.005535	0.004956	0.002896	0.006499	0.005507	0.011877
Index weight	0.148518	0.132969	0.077695	0.174368	0.147754	0.318696

It can be seen from table 3 that the index weights of fine particles (PM2.5), inhalable particles (PM10), sulfur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2) and ozone (O3) are respectively 0.148518, 0.132969, 0.077695, 0.174368, 0.147754, 0.318696. The main factor of air quality in Beijing is O3 concentration, followed by CO concentration. The effect of SO2 on air quality in Beijing is not obvious.

Based on the original data of Beijing air pollutants, according to formula (7) to formula (9), according to table 2 standard, the membership degrees of different pollutants in each quarter of each year are calculated, and the membership degrees of six pollutants in each quarter of each year are 0, that of SO2 and NO2 are 0, that of CO is 2 to 6, and that of CO is 0 Degrees are all 0.

According to formula (10) and multiplying the membership degrees of different pollutants by their respective weights, the data of air pollutants belong to the weighted membership degrees of different pollution levels. Add the membership degrees of different pollutants of the same level to get the membership degrees of different pollution levels in the evaluation area. See Table 4 for specific data.

Table 4 comprehensive assessment results of air quality in Beijing from the first quarter of 2014 to the first quarter of 2019

Time	Leve one	Leve two	Level three	Composite score
The first quarter of 2014	0.553377	0.265936	0.180687	88.72689
The second quarter of 2014	0.335924	0.642474	0.021603	88.14321
The third quarter of 2014	0.383203	0.584394	0.032404	88.50799
The fourth quarter of 2014	0.60622	0.304915	0.088865	90.17355
The first quarter of 2015	0.5826	0.308955	0.108445	89.74154
The second quarter of 2015	0.411549	0.58305	0.005401	89.06148

The third quarter of 2015	0.48583	0.51417	0	89.8583
The fourth quarter of 2015	0.603265	0.245937	0.150797	89.52468
The first quarter of 2016	0.641915	0.336482	0.021603	91.20312
The second quarter of 2016	0.393018	0.597908	0.009074	88.83944
The third quarter of 2016	0.506795	0.493205	0	90.06795
The fourth quarter of 2016	0.591445	0.256227	0.152328	89.39117
The first quarter of 2017	0.60445	0.333443	0.062107	90.42343
The second quarter of 2017	0.433077	0.566923	0	89.33077
The third quarter of 2017	0.486309	0.513691	0	89.86309
The fourth quarter of 2017	0.770284	0.229716	0	92.70284
The first quarter of 2018	0.659997	0.340003	0	91.59997
The second quarter of 2018	0.417236	0.58064	0.002125	89.15111
The third quarter of 2018	0.650602	0.349398	0	91.50602
The fourth quarter of 2018	0.735673	0.264327	0	92.35673
The first quarter of 2019	0.71607	0.28393	0	92.1607

From table 4, it can be seen that in the first quarter of 2014, the subordination degree of air quality in Beijing was 0.553377, that of the city was 0.265936, that of the city was 0.180687, and that of the city was 0.265936, that of the city was 0.180687. The final evaluation result shows that the city's air quality belongs to the first level, and the comprehensive score of air quality was 88.72689. In the first quarter of 2019, the subordination degree of the city's air quality belongs to the first level is 0.71607, the subordination degree of the second level is 0.28393, and the subordination degree of the third level is 0. The final evaluation result shows that the city's air quality belongs to the first level, and the comprehensive score of the city's air quality is 92.1607. In 2014, 2015 and 2017, the air quality of the first quarter and the fourth quarter of Beijing was classified as level 1, the air quality of the second quarter and the third quarter of Beijing was classified as level 2, the air quality of the first quarter, the third quarter and the fourth quarter of Beijing in 2016 and 2018 was classified as level 1, and the air quality of the second quarter was classified as level 2. Beijing's air quality was better in the first quarter and the fourth quarter, belonging to the first level, while it was relatively poor in the second and third quarters. Beijing's air quality is first class in two quarters of 2014 and 2015, second class in two quarters and first class in three quarters of 2018, and second class in one quarter.

Figure 1 change trend of air quality comprehensive score in Beijing

Figure 1 shows the change of comprehensive scores of air quality assessment of Beijing from the first quarter of 2014 to the first quarter of 2019. It can be seen from the figure that from 2014 to 2019, Beijing's air quality score shows a gradual upward trend, which indicates that Beijing's air quality is gradually optimized.

DISCUSSION AND CONCLUSION

In this paper, the entropy theory of information theory is introduced into the calculation of air quality evaluation, and the weight coefficient is calculated by the utility value of information disorder reflected by the data itself, so as to effectively reduce the impact of subjective factors. By introducing the improved grey clustering model of entropy weight, the evaluation method is enriched and improved, and the calculation of the evaluation model is simple, convenient and the result is reasonable. Finally, the following conclusions are reached:

1. The main factor of air quality in Beijing is the concentration of O3, followed by the concentration of CO. The effect of PM2.5, PM10 and NO2 is similar. The effect of SO2 on air quality in Beijing is not obvious.
2. The degree of subordination of six pollutants in each quarter of each year in Beijing is 0, and the air quality of Beijing is better in the first quarter and the fourth quarter, which is slightly worse in the second quarter and the third quarter.
3. From 2014 to 2019, Beijing's air quality score shows a gradual upward trend, and Beijing's air quality is gradually optimized.

REFERENCE

Fu, B.L., Wei, W.H., Chen, R.Y., Application of fuzzy comprehensive analysis based on entropy weight in air quality assessment [J]. Journal of Liuzhou Vocational and technical college, 2007 (02): 83-86

Gao, M., Wu, X.P., Analysis of influencing factors of air quality in Beijing based on Entropy Weight Grey Correlation Method [J]. Ecological economy, 2017,33 (03): 142-147

Hao L., Wang R., Zhao Y., Fang K., Cai Y., The enzymatic actions of cellulase on periodate oxidized cotton fabrics, Cellulose 25 (2018) 6759-6769.

He, A.X., Wei, Q.L., Fan, K.Q., Ding, M.Q., Study on comprehensive evaluation of air quality in Hefei Based on grey clustering method [J]. Journal of Anqing Normal University (NATURAL SCIENCE EDITION), 2019,25 (01): 99-103 + 112

Li, J.B., Performance evaluation of haze control in Beijing Tianjin Hebei Urban Agglomeration [J]. Journal of China Environmental Management Cadre College, 2019,29 (02): 60-64

Liu, B., Hu, T.R., Lv, L.W., Experience and Reflection on Collaborative haze management in Beijing Tianjin Hebei region [J]. Journal of China Environmental Management Institute, 2018,28 (06): 8-11

Liu, H.J,, Lei, M.Y., The dilemma of collaborative governance in China's haze pollution areas and its solutions [J]. China population, resources and environment, 2018,28 (10): 88-95

Liu, H.Q., Zhang, X.Q., Attribute recognition model based on entropy weight for air quality comprehensive evaluation [J]. Environmental science and technology, 2008 (07): 141-143

Li, Y.R., Wang, J.X., Han, T.T., Wang, Y., He, D., Quan, W.J., Ma, Z.Q., Using multiple linear regression method to evaluate the impact of meteorological conditions and control measures on air quality in Beijing during APEC period [J]. Environmental science, 2019,40 (03): 1024-1034

Ma, Y.Q., Yang, H.Y., Pan, P.Q., Improvement and application of grey cluster correlation analysis method [J]. Practice and understanding of mathematics, 2013,43 (19): 166-172

Song, L., Luo, L., Song, J., Zhang, H., Li, X., Cheng, S., Wang, F. (2017). Enhanced photodegradation activity of hydrogen-terminated Si nanowires arrays with different-oriented crystal phases. Catalysts, 7(12), 371.

Sun, L.N., Wang, K., Sun, W.N., Comparative study on "2 + 26" urban air quality comprehensive evaluation [J]. Journal of Chongqing University of science and Technology (NATURAL SCIENCE EDITION), 2019,21 (02): 113-116

Sun, X.L., Zhu, J.M., He, X.J., Research on urban air quality based on fuzzy comprehensive evaluation and factor analysis [J]. Journal of natural science, Harbin Normal University, 2017,33 (06): 5-10

Tao, Y.S., Li, Y.M., Zhang, X.X., Zhang, Y., Chengdu air quality analysis based on fuzzy comprehensive evaluation and grey correlation [J]. Experimental science and technology, 2017,15 (06): 188-191

Wang R., Yang C., Fang K., Cai Y., Hao L., Removing the residual cellulase by graphene oxide to recycle the bio-polishing effluent for dyeing cotton fabrics, J Environ Manage 207 (2018) 423-431.

Wang, H.W., Gu, J., Chen, M.L., Comprehensive evaluation of pollution industry concentration and air pollution emission [J]. System engineering, 2016,34 (11): 59-63

Wang, K., Yue, D.P., Air quality evaluation of Zhengzhou based on double weight fuzzy comprehensive model [J]. Journal of Jiangxi agriculture, 2018,30 (10): 100-105

Xie, Q.J., Lu Yuling, Zhu, J.M., Zhou, J.B., Research on quantitative collection of haze tax based on fuzzy comprehensive evaluation [J]. Journal of Huaiyin Normal University (NATURAL SCIENCE EDITION), 2017,16 (02): 113-118

Xu P., Research and application of near-infrared spectroscopy in rapid detection of water pollution, Desalination and Water Treatment, 122(2018)1-4.

Xu P.; Na N.; Gao S.; Geng C., Determination of sodium alginate in algae by near-infrared spectroscopy, Desalination and Water Treatment, 168(2019)117-122.

Yang, S.J., Wang, A.P., Zheng, X.X., Entropy weight coefficient method of basic farmland index decomposition [J]. Resource development and market, 2006 (04): 305-306 + 314

Yao, X.Q., Li, Y.Z., Xu, Y., Chen, J.H., Zhou, P., Comprehensive evaluation of air quality in Chengdu based on entropy weight method and cluster analysis [J]. Environmental protection science, 2017,43 (01): 100-104

Yu, W.Y., Zhang, S.J., Shen, H.T., Wang, R.D.. Research on the construction and application of air quality comprehensive evaluation model based on the air quality evaluation index of Chengde City, Hebei Province [J]. Economic research reference, 2018 (58): 75-80

Zhang, H.E., Ma, M.Q., Wang, X., Fuzzy evaluation of the change of ambient air quality in the main urban area of Lanzhou City from 2001 to 2015 [J]. Resources and environment in arid areas, 2017,31 (12): 117-122

Zhibin Liu, Ming Liu, Quality Evaluation of Environmental Accounting Information Disclosure of China's Thermal Power Listed Companies, Journal of Applied Science and Engineering Innovation, 2019, 6(2), 72-75.