

The Factor Analysis of PM_{2.5} Calculating and Source Structure in Jiangsu Province

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Abstract-PM_{2.5} have got people's attention nowadays, people's concentration about air quality have reached a very high level. In this paper ,we take Jiangsu Province for an example.Selecting the PM_{2.5} data and economic indicators for each city in a time period to analyze the relation between PM_{2.5} and GDP ,industrial structure, electric power consumption, housing construction area and the vehicle ownership. The results show that all these facts are important in affecting the formation of PM_{2.5} .And decrease in the affection level.

Keywords-PM_{2.5}; influencing factor; measurement ;city; suggestion

I. INTRODUCTION

PM (particulate matter) are known as the particulate matter, including total suspended particle and respirable particulate matter. Total suspended particle, which diameter is bigger, is not easy to be absorbed by human body. Particulate matter,including coarse particles and fine particulate matter. PM_{2.5} is the fine particulate matter in the atmosphere and the diameter is less than or equal to 2.5. Although the fine particulate matter composition of Earth's atmosphere just a few ingredients content, but it has important effect on visibility and quality of air. Fine particles are small in particle size, rich in a lot of toxic and hazardous substances, long in residence time in the atmosphere, far in transmission distance. Thus a great impact on human health and environmental quality of the atmosphere

This article attempts take Jiangsu province as an example, To illustrate the current situation PM_{2.5} pollution in Jiangsu Province and PM_{2.5} pollution caused by factors, In order to provide ideas in solving environmental problems of PM_{2.5} pollution. Using the way of analyzing the trend of change in PM_{2.5} value of 13 cities in Jiangsu during January 15, 2013 to January 31, and relationship between economic indicators and city development indicators.

II. REVIEW OF THE LITERATURE

Since it hasn't been a long time after the PM_{2.5} went into people's view, there are less research on PM_{2.5} from the literature in the past. The main aspects of the research involving PM_{2.5} source apportionment and PM_{2.5} pollution control from the literature existed.

By analyzing the source of PM_{2.5} at 4 sites in Nanjing for a 7-day source apportionment of PM_{2.5} in both summer and winter. Huijun Huang discovered the source contributions of PM_{2.5} aerosols in Nanjing, respectively dust 37.28% and coal soot, sulfate, 30.34%, auto dust 2.98%, smelter dust and other sources 9.01%[1]. Zheng Bao build a source and receptor Hangzhou PM_{2.5} and PM₁₀ chemical composition of the spectrum, using a chemical mass balance (CMB) receptor model to resolve its source, PM₁₀ and PM_{2.5} pollution heavier, dust, vehicle exhaust dust, sulfates and coal smoke is a major source of emissions of PM₁₀ and PM_{2.5} of Hangzhou [2].

The analysis above indicates that, although the major sources of PM_{2.5} are coal-burning, dust, vehicle emissions, construction dust and biomass burning, there contributions to PM_{2.5} vary greatly. Even more important is that research has mainly focus on the natural science and other technical means to study the composition of PM_{2.5} problems, as from the economics of urban economic development, a study on the relationship between PM_{2.5} and rarely[3].

III. PM_{2.5} EMISSIONS OVERALL STATUS OF CITIES IN JIANGSU PROVINCE

In the national standard of the People's Republic of China (GB3095-2012),The evaluation standard of PM_{2.5} as shown in Table 1.

TABLE 1:PM2.5 EVALUATION CRITERIA

Level-1 0-50	Superior	Normal activities
Level-2 51-100	Good	Cooking, heating and burning pollution
Level-3 101-150	Minor industrial pollution: All kinds of mineral and metal powder	Few have mild symptoms aggravate susceptible
Level-3 151-200	Mild transportation pollution: Transport emissions of exhaust	Some symptoms may occur in healthy people
Level-4 201-250	SO ₂ high degree of pollution in the air	Symptoms significantly increased in patients with heart and lung disease
Level-4 251-300	NO ₂ high degree of heavy pollution in the air	Severely irritating to respiratory system
Level-5 >300	Severe pollution: Major releases from CH ₄ , terpenes	Healthy people could decrease stamina, with obvious discomfort

Note: Unit is microgram/cubic meter in Table 1.

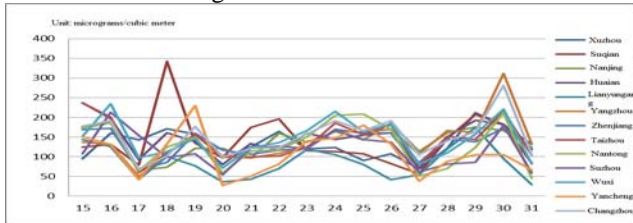


Figure.1: Cities in Jiangsu Province PM_{2.5} line chart from January 15,2013 to 30th

In the Fig.1 most of indicators are in the city on the three levels of pollution standards set by the State.PM_{2.5} values in some cities even have reached the four-level pollution standards. Every city has the PM_{2.5} concentration of individual observation point at 985 micrograms/cubic meter. Reaching severe levels of pollution[4].

The development trend of the cities shows that synchronicity between the various cities are different. Most of the city are between 21st and 26th,PM_{2.5} concentrations have been risen to 200 micrograms/cubicmeter.On the 27th the PM_{2.5} concentrations were significantly decreased in 13cities.High PM_{2.5} concentrations from 21st to 26th position, mainly because duringthis time, there was a relatively stable weather conditions in Jiangsu Province[5]. On the 27th, as the stable weather and climate changed, synchronize PM2.5 values in 13 cities declined. Thus it can be assumed that stable climate and environment is an important reason for the accumulation of PM2.5 concentrations.

IV. ANALYSIS OF THE RELATIONSHIP BETWEEN SOCIO - ECONOMIC FACTORS AND PM_{2.5}

In the previous article. The main source of PM2.5 are coal dust, dust, vehicle emissions, architecture, biomass combustion, So we select out those economic factors which have an impact on the sources that mentioned. Such as GDP and industrial structure, openness, housing

construction area, urban per capita disposable income, consumption, urbanization rate, the number of car ownership. Compared with concentrations of PM_{2.5} values, economic factors that associated with PM_{2.5} can be observed.

A .GDP of each city

High or low GDP level is closely related with economic growth of the city. Economic activity may lead to resource consumption and contaminated waste emissions. Faster the city's economy growth, more frequent the economic activities are. When the contaminated waste emissions released by economic activities over the decomposition and capacity of natural and man-made environment. Economic growth will have a significant negative impact on the environment[6]. So GDP is an influential factor of the PM_{2.5} factor.

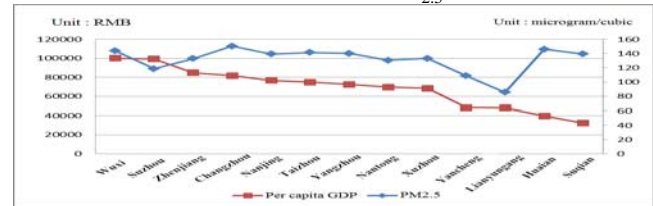


Figure.2:The city's per - capita GDP and the PM_{2.5} analysis diagram

According to the information in Fig.2, it can be seen that Zhenjiang, Changzhou, Nanjing, Taizhou, Yangzhou, Nantong, Xuzhou, Yangcheng and Lianyungang, these city's GDP roughly the same synchronization with the PM_{2.5}. In Xuzhou, Lianyungang, Yangcheng, the contrast can be seen in the three cities clearly. These three cities which GDP is lower PM_{2.5} concentrations are at a lower level. Huaian and Suqian's GDP were lower but there levels of PM_{2.5} were higher than the overall state. This situation occurs because :(1) each city has a different industrial structure, in some areas the primary sector is the main source of GDP. In some other city secondary industry is the main source of GDP, If the secondary industry possess a larger proportion will lead to higher PM_{2.5} values.(2) Treatment of industrial pollution levels in some areas is comparatively backward, So PM_{2.5} values of these areas will be higher than those are in developed industrial extent but handle high levels of industrial pollutants than their regions.

B.The industrial structure

The environmental impact of industrial structure is obvious, the industrial structure of our country is mainly with the second industry, so I will be the secondary industry output value as the measure of the industrial structure. The second industry is refers to mining industry, manufacturing industry, electric power, gas and water production and supply industry, construction industry. Secondary industry as a whole in terms of energy consumption and wastegeneration of pollutants accounted for the entire industrial structure alarge proportion of energy consumption, pollutants from waste, the primary industry of agriculture and tertiary industry services and other sectors of energy consumption, waste discharge in the case of the creation of the same output is much lower. If the second industrial city accounted for the greater proportion of the industrial structure, the city's environmental contamination may be the greater. So the

proportion of secondary industry output value is selected for the index.

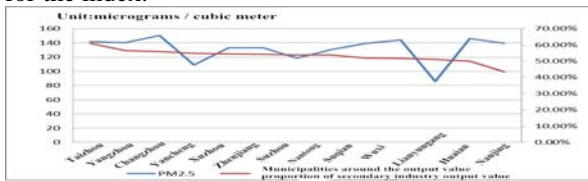


Figure.3: Relationship between the proportion of secondary industry output and PM_{2.5}

According to the information in Fig.3, it can be seen that 13 cities all over the secondary industry output are between 40% to 60%, PM_{2.5} concentrations ranging from 130-140 micrograms / cubic meters, you can say the gap is not very big. The value is the proportion of secondary industry in a stable sort from highest to lowest, but the value of PM_{2.5} did not appear with the proportion of secondary industry output value that match the municipalities downward trend. In Yancheng and Lianyungang, there's a relative Valley value of PM_{2.5}[7]. Yancheng is about 108 micrograms / cubic meter, about 85 micrograms /cubic meter of Lianyungang, Huai' An and Nanjing, Wuxi, Changzhou City, PM_{2.5} are relatively high, And their proportion of secondary industry output in at around 50%, Compared with the Yancheng and Lianyungang, there are two reasons for this situation occurs: (1) Treatment of industrial pollutants is not enough. (2) Stable inland climate.

C. Housing construction area

City dust occupied a large share in the composition of PM_{2.5}. In the process of urban real estate development and construction, demolishing old housing, construction and the transportation of construction material will produce a lot of dust. For example, the truck carrying sand drive on the city street, area near the construction site dust is spread everywhere. It can be seen that in the process of housing construction it release large numbers of dust in the air. So I will take house area as the testing index.

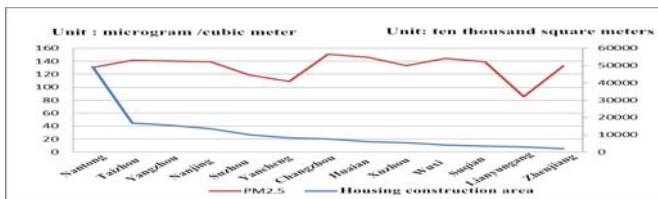


Figure.4: The relationship between urban housing construction area and PM_{2.5}

According to the information in Fig.4 we can see: the number of Nantong city's housing construction area are 493.2237 million square meters, 474.2902 million square meters larger than Zhenjiang which has the least housing construction area, 324.6302 million square meters higher than Taizhou which has the second largest housing construction area. From the housing construction area which can be observed in Fig.4 it has no significant impact on PM_{2.5}. Of course, housing construction area of the city's urban area based on the size of the city. If a city

has large urban area, and low in housing construction area, or it has a smaller urban area, large housing construction area, The reflection on PM_{2.5} will be different.

D. Electric power consumption

The city's electricity consumption can be substantially equivalent to the generating capacity of the city power plant. It is known that coal-fired power plants in a large proportion in China, followed by hydropower. Thermal power process is the most polluted. In China coal-fired power is the most basic power, as a traditional way of power generating it has its drawbacks and deficiencies. Such as direct coal combustion emissions of SO₂, NO_x and other acid gases growing, making China's acid rain increased, dust pollution adversely affect people's lives and the growth of plants. So we think the city electricity use will have an impact on the formation of PM_{2.5}.

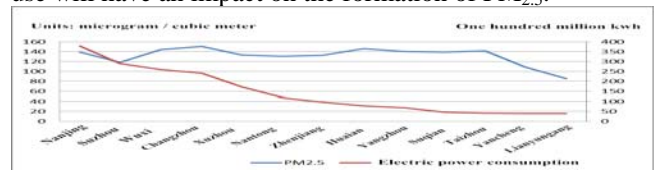


Figure.5: The relationship between PM_{2.5} and Electric power consumption

According to the information in Fig.5, sequenced by the city's electricity consumption from higher to lower, the downward trend in PM_{2.5} formation is not so obvious than the downward trend in electric power consumption. But correlation is still showed between these two trends. Electricity consumption is at a higher level in Nanjing and Suzhou while PM_{2.5} concentrations are relatively low[8]. I think this is because of the existence of differences in city's power structure; As it mentioned above, China's power structure can be divided into thermal power, hydroelectric power and nuclear power. In Jiangsu Province, thermal power and hydroelectric power form most of the power structure. Coal-fired power causes the most serious air pollution, followed by hydropower. While nuclear power causes minimal air pollution. Although Nanjing and Suzhou generally use coal-fired power, the use of energy-efficient coal-fired technology and handling of contaminants is also very efficient. While having a nuclear power plant in Lianyungang, some of the information presented in Fig.5 shows that in Lianyungang Yancheng and Taizhou electric power consumption mostly the same but PM_{2.5} value is much lower than concentrations in other areas.

E. Vehicle ownership

vehicle ownership affects vehicle tailpipe emissions directly, vehicle exhaust in the atmosphere affect PM_{2.5} formation.

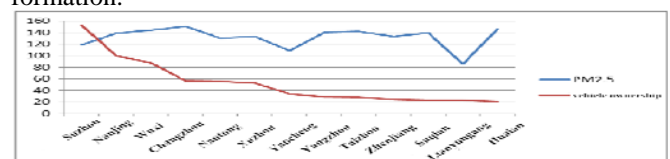


Figure.6: Relationship between PM_{2.5} and Vehicle volume

According to the information in Fig.6, Changzhou, Wuxi, Suqian, Lianyungang, Nantong, Xuzhou's PM_{2.5}

values synchronized with its vehicle volume. Huaian, Zhenjiang, Yangzhou, Taizhou, these four cities' PM_{2.5} values do not synchronize showing a downward trend in comparison with vehicle ownership[9]. Huaian has a minimum vehicle ownership of 210200, PM_{2.5} values were about 146.2 mg/m³. The highest vehicle ownership is in Suzhou as 1.5189 million, PM_{2.5} is 118.8 mg/m³. The reason that resulted in Xuzhou and Huaian's situation could be: density of road traffic, distance that vehicles travel, size of the city, exhaust gas processing capacity.

F. Test and measurement of PM2.5 related factors

The passage above describes the relationship between PM_{2.5} and the city's per capita GDP, industrial restructuring, housing construction area, electricity and vehicle volume. Show the relationship between PM_{2.5} and various economic variables visually. Next we will create a simple linear regression model, expecting a better understanding of the relationship between PM_{2.5} and the overall economic variables and have a measurement of various economic variables contribution to PM_{2.5}.

Based on PM_{2.5} concentrations for the explained variable (Y), To the GDP, industrial structure, housing construction area, electricity, vehicle ownership as explanatory variables, defined respectively as X₁, X₂, X₃, X₄, X₅. In order to eliminate the heteroscedasticity, the original data are put in natural logarithm. Perform a simple linear regression model by SPSS16.0, regression analysis results shown in table 2 and table 3.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.951 ^a	.905	.836	.01633

a. Predictors: (Constant), VAR00006, LNX2, LNX3, LNX4, LNX1

TABLE.2: REGRESSION MODEL STATISTICS

The fitting of the model is reflected in the table.2, correlation coefficient R =0.951, Shows that the correlation is very large, fitting coefficients R² =0.905, fitting coefficients adjusted for 0.836, Fitting effect model is better than thought.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.860	.039		47.432	.000
	LNX1	.048	.009	.524	5.298	.001
	LNX2	.321	.084	.278	3.837	.006
	LNX3	.016	.007	.154	2.443	.045
	LNX4	.035	.010	.312	3.410	.011
	LNX5	.026	.011	.298	2.476	.042

Figure.7: Coefficients of regression equations

Seen from the table.3, the equation regression coefficient through by the 5% significance level test, regression equations are obtained as follows:

$$LNY=0.524LNX_1+0.278LNX_2+0.154LNX_3+0.312LNX_4+0.298LNX_5$$

It can be seen from the equation that various economic variables are important factors causing the concentration of PM_{2.5} increases. Judging from the coefficients of each

explanatory variable, the size of these variables' impact on PM_{2.5} is listed as follows: the city GDP, consumption, vehicle ownership, industry structure, housing construction area.

V.COUNTERMEASURES AND SUGGESTIONS

The situation of urban air quality is worrisome. Regional haze problems are becoming increasingly prominent. In order to reduce PM_{2.5} concentrations effectively and improve air quality, this article try to put forward counter measures in the following aspects.

(1) Change the extensive way of development; promote adjustment of the industrial structure

From the analysis above,the regional GDP and industrial structure, to a large extent , influence the levels of PM_{2.5} pollution.The total economy of Jiangsu Province are in a leading position in the whole country,however, environmental harm is large,Because of the overall low industrial structure will produce more pollution[10]. As a developed provinces in eastern China, Jiangsu should take advantage of good economic advantages, technology and locational advantage.Besides, Jiangsu should accelerate the development of modern service industries, actively promote high-tech industries such as new energy, energy saving, environmental protection.Last but not least,Jiangsu should strengthen supervision , rectification of existing high-emitting industries and encourage voluntary reduction of production unit.

(2) Gradually improve the structure of energy consumption

Electric power consumption of a city has a certain impact on PM_{2.5} emissions.PM_{2.5} emissions is largely caused by coal-fired,which is Dominated in China's power generating, by thermal power have a share of 70% in total electricity generating. Jiangsu Province is not an exception anyway. Large amounts of thermal coal emissions SO₂, SO₂ is an important source of forming secondary particles of PM_{2.5}. Therefore, the Jiangsu province should gradually reduce its coal consumption, use subsidy mechanism to promote the use of wind, solar and other clean energy power supply capacity , promote the optimization of the energy structure and give full play to restructuring energy contribution in reducing PM_{2.5} pollution[11].

(3) Control the automobile exhaust pollution

As can be seen from the above research, Car ownership and PM_{2.5} pollution has a great relationship. Several studies have confirmed that the car tail gas is an important source of PM_{2.5}, It wants to reduce PM_{2.5} by control of automobile exhaust pollution. First of all, JiangSu province should strictly carry out the national standard to promote the out and updates of vehicle, at the same time, it can promote the standards emission and the maintenance of the vehicle by environmental tests; Secondly, it should promote the building of public transport, to improve the comfort and the accuracy of bus, build the atmosphere to encourage driving less. Finally, it should use science and technology means, from the technology of use of vehicle fuel and purification treatment technology of exhaust gas to control the exhaust emissions of the automobile.

(4) Strengthen the dust pollution control at construction housing construction site

Dust in the construction site is an important source of PM2.5, strengthen of the prevention of construction site online dust is an important aspect of the control of PM2.5 pollution. For housing construction site, in accordance with the principle department regulations "territorial management, the overall linkage, comprehensive management", the relevant departments will take inspections, investigations, exposure, accountability and assessment way, strictly control the dust pollution by urging the main responsibility of all the parties. The construction site should use the close management, when in the windy weather of grade 4, above grade 4 or fog weather, the construction which is easy to produce dust is forbidden. Cities should strengthen the patrolling and control works about field dust pollution, punishing those are not in conformity with the standards in order to control the construction site dust and reduce the pollution of PM2.5.

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