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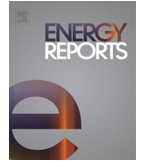
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An analysis on the current situation of energy development and its environmental problems in Yulin City

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Abstract

This paper has done research on the current situation of energy development and its problems in Yulin for improving the coordinated development between economy and ecological environment. Through the current situation analysis of the principal energy development and environmental pollution, it is found that the industrial “three wastes” come mainly from the derivatives of the energy development and utilization process, and the enterprises with the biggest amount of industrial waste are from the energy industry, of which the extensive development and utilization of principal energy is one of the main reasons for the high emission load of industrial “three wastes”. Combined with the Environmental Kuznets Curve Theory, it is found that the EKC of industrial wastewater discharge is in the shape of inverted “N”, while the EKC of industrial exhaust and solid wastes discharge are in the shape of “N”. In order to realize the coordinated development of energy development and environment, it should pay attention to the classification and collection of industrial wastewater as well as the transformation of treatment mode in the future development, promote biological technology to control industrial exhaust from terminals, and strengthen the utilization of main industrial solid wastes at the same time.

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Keywords: Energy development and utilization; Environmental quality; Environmental Kuznets Curve; Industrial “three wastes”; Yulin City

1. Introduction

Since Grossman and Krueger [1] first proposed the Environmental Kuznets Curve Theory, international scholars have started to pay attention to the empirical study of it. Selden and Holtz [2] studied the relationship between CO₂ emissions and revenues in panel data from 130 countries from 1951 to 1986, and found the existence of the inverted U-shaped curve. Through the analysis of panel data of developed and middle-income countries from 1974 to 1989, Kaufmann et al. [3] found that the relationship of SO₂ concentration in the environment and per capita

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income is in the shape of inverted “U”. Since 2000, China’s scholars have gradually started to study the application of EKC Theory in China. Through the analysis of China’s six kinds of major pollution parameters from 1985 to 2003, Bao and Peng [4] found that the growth of per capita GDP is the reason for the increasing of pollution discharge. Kang and Wang [5] verifies the existence of EKC in China and found that foreign trade can help to slow China’s environmental pollution. Through the analysis of industrial “three wastes”, Fang et al. [6] believed that the economic development of Guangdong Province from 1997 to 2007, to a certain extent, was based on environmental pollution.

As a typical energy resource city, Yulin is regarded as the energy base of China in the 21st century because of the various types of energy and mineral enriched in one place [7]. With the rapid development of the domestic economy and the increasing demand for energy, the economy of Yulin has entered a stage of rapid development by virtue of its own energy advantages. The per capita GDP of this city has ranked in the first place for 10 consecutive years in Shanxi province since 2009 [8]. Through the current situation analysis of energy resource development and environmental pollution in Yulin, this paper explores the influence of energy development process on the environment, so as to provide a theoretical basis for the coordinated development between energy resource development and the environment in the future.

2. The development and utilization of principal energy

(a) Yulin, a principal source of “Transporting Coal from West to East”, has 146 billion tons of proved coal reserves, accounting for 8.76% of China [9]. Its coal resources mainly distribute in Shenmu, Yuyang, Fugu and Hengshan. From Fig. 1(a), the proved coal reserves of the 4 areas account for 89%. There are 268 coal mines and 28 large-scale coal chemical plants. As is drawn in Fig. 1(b), the output of raw coal shows an increasing trend in general. The output value remained stable from 2014 to 2016 due to the general decrease in raw coal price in China. As price picks up, the production keeps growing at an annual rate of 10% since 2016.

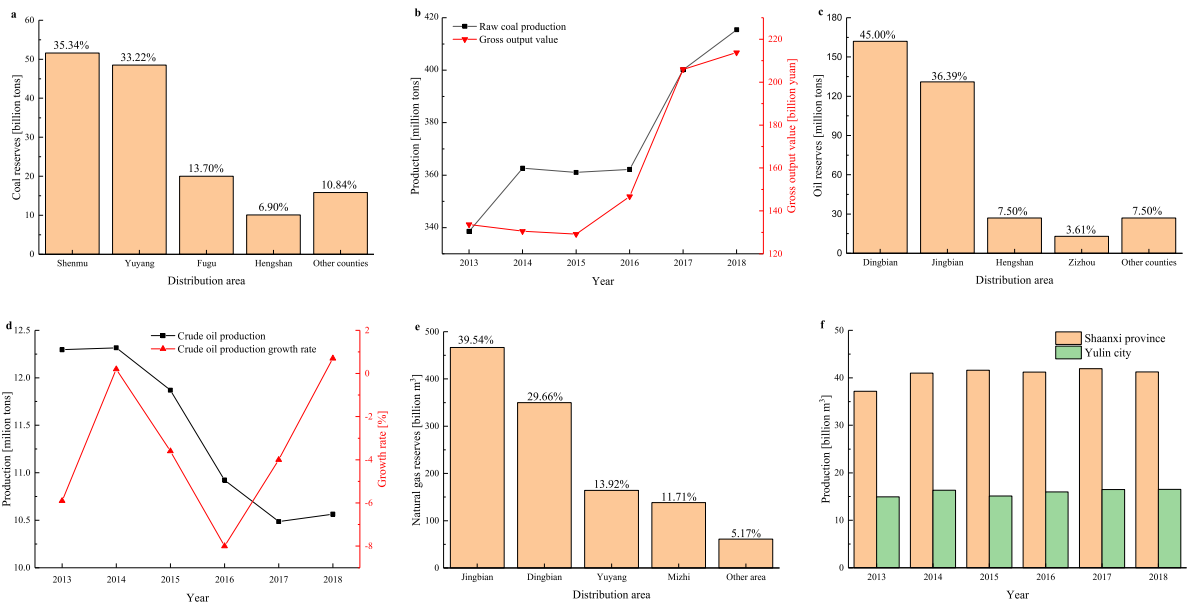


Fig. 1. (a) Distribution of proved reserves of coal; (b) Raw coal and its value; (c) distribution of proved reserves of oil; (d) crude oil production and growth rate; (e) distribution of proved reserves of natural gas; (f) natural gas output of Shanxi Province and Yulin City.

(b) Oil resource is mainly distributed in Dingbian and Jingbian which lie in the western part of Yulin. From Fig. 1(c), the sum of proved oil reserves of these two areas accounts for 81.39% of the total proved oil reserves. Yulin has a totally 33,428 oil wells and its oil output accounts for 80% of the whole province. As is shown in

Fig. 1(d), the crude oil output decreased from 2014 to 2017 and then stabilized at about 10.5 million tons in the last two years.

(c) Yulin, a hub of “West-to-East Gas Transmission”, has a large proved reserve of natural gas that amounts to 1.18 trillion m³ and is responsible for supplying gas to more than 20 large and medium-sized cities in China such as Beijing, Xi’an, Shanghai and so on [10]. It can be seen from Fig. 1(e), natural gas of this city is mainly distributed in Jingbian, Dingbian, Yuyang and Mizhi. From Fig. 1(f), the natural gas output of Yulin is about 16 billion m³, accounting for about 40% of the whole province.

Apart from these three kinds of principal energy: coal, oil and natural gas, Yulin also contains 360 million tons of kaolin, 4.36 million tons of quartz sand, 120 million tons of bentonite, 500 million tons of limestone and 100 million tons of iron ore. The annual energy contribution to the country is worth more than 60 billion yuan. This city will become the most influential resource-based city on the New Silk Road under the influence of “the Belt and Road”.

3. The effect of ecological environment

3.1. The current situation of environment pollution

The development and utilization of energy makes the economy develop rapidly. However, environmental pollution brought by economic development is becoming more and more serious. Industrial “three wastes” have become a key factor of affecting the ecological environment in Yulin [11]. The amount of industrial “three wastes” from 2009 to 2017 is shown in Fig. 2. Petroleum, COD (chemical oxygen demand) discharge, ammonia nitrogen and fluoride are the main water pollutants. And oil pollution was the principal pollutants, followed by the COD discharge, whose pollution sharing rate was 29.65% and 17.52% respectively. From Fig. 2(a), the volume of wastewater discharge from 2009 to 2013 is basically stable but it increases gradually after 2013. Especially after 2016, it increases significantly. Abilities to cope with wastewater has generally been on the rise. However, there was a decline in 2017, which give rise to a dramatic increase in industrial wastewater discharge.

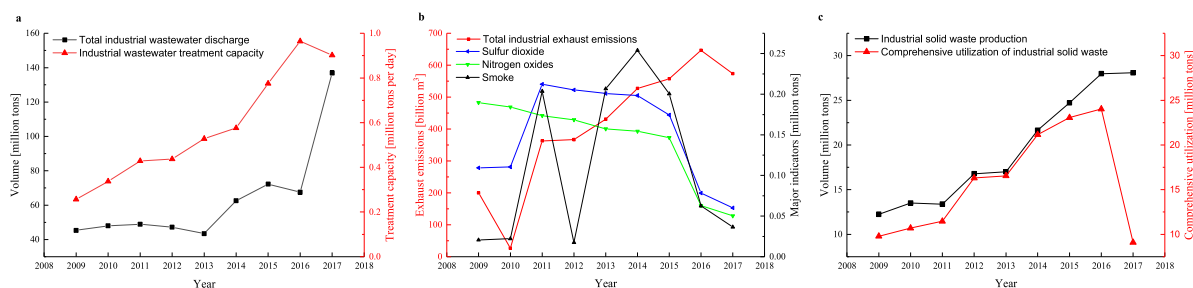


Fig. 2. (a) Industrial wastewater discharge; (b) Industrial exhaust emissions; (c) Production of industrial solid waste.

The atmosphere of Yulin has an obvious characteristic of compound pollution. More than 80% pollutants are gathered in Shenmu, Fugu and Yuyang. The main heavy-pollution industries are coking, thermal power generation, inorganic salt manufacturing, cement manufacturing. It can be seen from Fig. 2(b), the total volume of industrial exhaust emissions from 2009 to 2016 increased yearly, but it decreased since 2016. The curve of sulfur dioxide emissions shows an “n” trend; the curve of nitrogen oxide emissions generally shows a downward trend; from 2014 to 2017, smoke emissions was gradually decreased. Despite the improvement in air quality, the overall situation was still not optimistic.

According to statistics [12], enterprises producing industrial solid waste in Yulin area come from coal washing industry, chemical industry and mine in recent years. The largest output of industrial solid waste is coal gangue, followed by fly ash, slag and so on. It is obvious that energy development has caused some serious environmental problems. As is shown in Fig. 2 (c), the production of industrial solid waste increased year by year. Comprehensive utilization volume of it from 2009 to 2016 was basically equal to that of production. Combined with Fig. 1, it finds

that the output of principal energy increased in 2017. There is no doubt that a large amount of energy output will be bound to put more pressure on the environment. This may be the reason why there is a huge gap between the comprehensive utilization volume of industrial solid waste and the amount produced in 2017.

Through the analysis of the current situation of environmental pollution, it shows that the development and utilization of energy resources is the main reason for the high emission load of industrial “three wastes”. In other words, the development and utilization of energy resources is the main factor affecting the ecological environment of Yulin.

3.2. Environmental Kuznets curve theory

Environmental Kuznets Curve Theory is selected to study the relationship between economic growth and environmental pollution [13]. In the empirical study of the Environmental Kuznets Curve, it usually selects economic growth indicator as the independent variable, and environmental quality indicator as the dependent variable to build the econometric model. The measurement model selected should have certain statistical significance, which can ensure the accuracy required by statistics. Secondly, it should have practical significance, which can give reasonable explanations to the relevant relationships between indicators.

The Pearson correlation between per capita GDP and industrial “three wastes” emission in Yulin from 1995 to 2017 has been analyzed with the help of SPSS software. The Pearson correlation coefficients of the per capita GDP between industrial wastewater discharge, industrial exhaust emission, and industrial solid wastes production are respectively 0.886, 0.931 and 0.940, which are all with significant correlation. Thus, it has scientific instructions to establish the measurement model between per capita GDP and industrial “three wastes”.

Therefore, this paper selects the following measurement models to make calculation and analysis.

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \beta_3 x_i^3 \tag{1}$$

$$\ln y_i = \beta_0 + \beta_1 \ln x_i + \beta_2 \ln 2x_i + \beta_3 \ln 3x_i \tag{2}$$

In the formula: y_i is the discharge amount of industrial “three wastes” in the i year; x_i is the per capita GDP in the i year; β_0 is the constant term; $\beta_1, \beta_2, \beta_3$ are undetermined coefficients.

The correlation curve between different economic levels and environmental pollution can be obtained by model calculation. The relationship between the coefficients and the shape of curve is shown in Table 1 [14]. The industrial “three wastes” discharge and per capita GDP of Yulin from 1995 to 2017 are taken as the calculation indicators, and two kinds of econometric models are matched by Origin software, and the results are shown in Table 2.

Table 1. Coefficients and the shape of the curve.

Value of undetermined coefficients	Shape of EKC	The trend between economy and environmental pollution
$\beta_1 > 0, \beta_2 < 0, \beta_3 > 0$	“N”	With the growth of economy, the quality of environment deteriorates at first but improves when economy reaches a certain level, and then deteriorates again.
$\beta_1 < 0, \beta_2 > 0, \beta_3 < 0$	Inverted “N”	With the growth of economy, the quality of environment improves at first but deteriorates when economy reaches a certain level, and then improves again.

Table 2. The fitting results of industrial “three wastes” and per capita GDP.

Environmental pollutants	measurement model	β_1	β_2	β_3	R^2
Industrial wastewater	Cubic model	>0	<0	>0	0.887
	Logarithmic cubic model	<0	>0	<0	0.942
Industrial waste gas	Cubic model	>0	>0	>0	0.875
	Logarithmic cubic model	>0	<0	>0	0.896
Industrial solid waste	Cubic model	>0	<0	>0	0.914
	Logarithmic cubic model	>0	<0	>0	0.898

3.3. Discussion

According to the fitting results, taking the models with the largest fit indicators R^2 as the optimization model to draw the Environmental Kuznets Curve of industrial “three wastes” shown in Fig. 3 respectively.

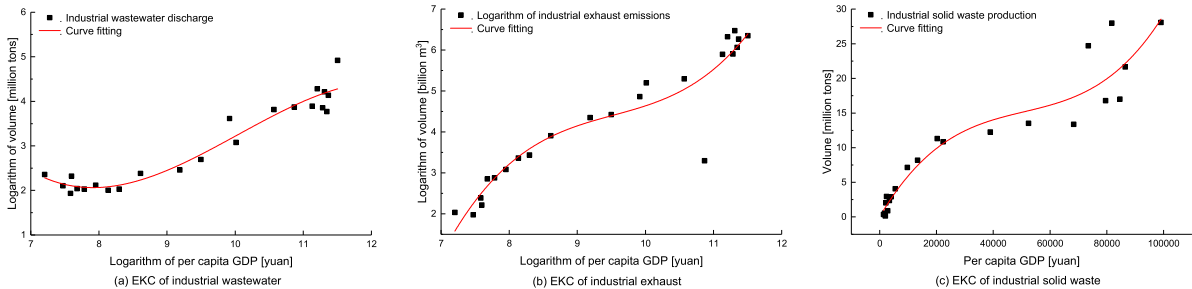


Fig. 3. (a) EKC of industrial wastewater; (b) EKC of industrial exhaust; (c) EKC of industrial solid waste.

(a) The EKC of industrial wastewater discharge is shown in Fig. 3(a). Undetermined coefficients correspond to an inverted “N” curve and it is now in the second half of this curve. After taking the derivative of the fitting function, it is found that when $\ln x$ is set at 7.915 and 12.157, that is, the per capita GDP is 2,738.047 yuan and 190,422.392 yuan, the first-order derivative of the function is 0, which means that when the per capita GDP is 2,738.047 yuan, the curve reaches minimum value, after this point, the increasing of per capita GDP will promote the discharge of industrial wastewater. In the meantime, it can be predicted that the curve reaches its maximum value when the per capita GDP is 190,422.392 yuan, that is, the further economic development after this point will be conducive to the reduction of the discharge of industrial wastewater.

When $\ln x$ is set at 10.035, that is, the per capita GDP is 22,811.042 yuan, the second-order derivative of the function is 0, which means that when the per capita GDP is less than 22,811.042 yuan, the EKC of industrial wastewater is concave, which means that the curve in the shape of “U”. While when the per capita GDP is larger than 22,811.042 yuan, the EKC of industrial wastewater is raised, which means that the curve in the shape of inverted “U”.

Many heavy industries and heavy pollution enterprises have been introduced into Yulin, which makes its economy develop rapidly but which causes great pressure on the environment. Energy industries such as power generation, petroleum processing occupy a large proportion in the industrial structure because the energy pattern of Yulin is dominated by coal. In 2017 alone, water used by industries reached 237 million tons. The large use of water in the industrial production process is the reason for the continuous increase in industrial wastewater discharge. As far as the current level of economic development in Yulin is concerned, it will take a long time for its per capita GDP to reach 190,422.392 yuan. Therefore, in future development, it should pay more attention to the classification and collection of industrial wastewater as well as the transformation of treatment mode.

(b) The EKC of industrial exhaust emission is shown in Fig. 3(b). Undetermined coefficients correspond to an “N” curve and it is now in the rising part of it. After taking the derivative of the fitting function, it is found that the first-order derivative is always greater than 0, which means that from 1995 to 2017, there was no extremum value of the EKC. When $\ln x$ is set at 9.514, that is, the per capita GDP is 13,548.078 yuan, the second-order derivative of the function is 0, which means that when the per capita GDP is less than 13,548.078 yuan, the EKC of industrial exhaust is raised, that is, the curve in the shape of inverted “U”. While when the per capita GDP is larger than 13,548.078 yuan, the EKC of the industrial exhaust is concave, that is, the curve in the shape of “U”.

Since Yulin popularized “Coal to Gas” project, industrial waste gas emissions have been increasing slowly after high-intensity control. Especially in the past two years, industrial emissions have been reduced due to the continuous increase in governance. The current situation has been improved, but it had better keep on strengthening the regulation on waste gas. In order to reach the incentive stage of reducing the discharge of industrial exhaust as soon as possible, in addition to continuing to reduce the discharge at the source, biological technologies should be promoted for treatment from terminals.

(c) The EKC of industrial solid waste production is shown as Fig. 3(c). Undetermined coefficients correspond to an “N” curve and it is now in the rising part of it. After taking the derivative of the fitting function, it is found that the first-order derivative is always greater than 0, which means that from 1995 to 2017, there was no extremum value of the EKC. When the per capita GDP is 50,870.497 yuan, the second-order derivative of the function is 0, which means that when the per capita GDP is less than 50,870.497 yuan, the EKC of industrial solid waste is raised, that is, the curve in the shape of inverted “U”. While when the per capita GDP is larger than 50,870.497 yuan, the EKC of industrial solid waste is concave, that is, the curve in the shape of “U”.

To sum up, heavy industry, military industry and machinery manufacturing industry account for a large proportion in the industrial pattern of Yulin. All of them will produce a large amount of solid waste, causing great damage to the environment. Although investment in harnessing industrial solid waste is increasing, the utilization efficiency of industrial solid waste is still lower than that of the national average. Especially, when there is a huge gap between the utilization and production of industrial solid waste, it will cause a serious effect on the environment. In order to avoid further pollution of the ecological environment by industrial solid waste, combined with the main sources of it in Yulin, coal gangue, fly ash and slag and other main industrial solid wastes can be used in the preparation of composite cement and the production of construction materials in the future environmental governance, so as to maximize the utilization of solid waste.

4. Conclusion

(1) The industrial “three wastes” come mainly from the derivatives of the energy development and utilization process, and the enterprises with the biggest amount of industrial wastes are from the energy industry, of which the development and utilization of energy is the main reason for the high emission load of industrial “three wastes”.

(2) The EKC of industrial wastewater is in the shape of inverted “N”, and is now in the second half of it. The EKC of industrial exhaust and solid wastes are in the shape of “N”, and are both on the rising.

(3) In order to realize the coordinated development of energy development and environment in the future development of Yulin, it should pay more attention to the classification and collection of industrial wastewater as well as the transformation of treatment mode, promote biological technology to control industrial exhaust from terminals, and strengthen the utilization of main industrial solid wastes at the same time.

Acknowledgments

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