Relationship between Economic Development Level and Environmental Quality in Qinghai Province

ZHAO Qing-lin[1*], MAO Wei[2], PENG Ying[3]

1. College of Life and Geographical Science, Qinghai Normal University, Xining 810008, China; 2. Graduate School, China University of Geosciences, Wuhan 430074, China; 3. Hunan Industry Polytechnic, Changsha 410208, China

Abstract Environmental and economic data in the years 1986 -2006 in Qinghai Province of China are selected. Based on Environmental Kuznets Curve (EKC) theory, models of per capita GDP and four environmental indices are established by SPSS software. Economic development level and environmental quality of Qinghai Province are simulated. Research shows that relationship between economy and environment of Qinghai Province does not completely accord with "U"-shaped Pattern of EKC. Fitting curve of the emission of industrial wastewater shows positive "U"-type, that of waste gas shows the right half of the "U" curve, and that of SO_2 and solid waste shows a "U + weak inverted U"-shaped curve. Result also indicates that water environment and air pollution of Qinghai Province are further deteriorated, and the SO_2 and solid waste emissions have shown a weak turning point in recent years. Suggestion of improving environmental quality is put forward, as well as optimizing the economic structure, adjusting the industrial structure, increasing investment in environmental protection, developing the comprehensive value of industrial waste actively, and raising people's awareness of environmental protection.

Key words EKC; Economic development; Environmental quality; Qinghai Province, China

Environmental Kuznets Curve (EKC) Model is a conception put forward by Grossman *et al.*, environmental scientists in the United States, at the 1990s. They point out that the pollution level of a country or a region will rise with the increase of income until reaching a certain degree of economic development; and then it will decrease with the income increase, showing a "U"-type curve. After the advance of this theory, experts and scholars all over the world have conducted empirical study on economic growth and environmental pollution from different angles. They have obtained different conclusions according to different fields and research objects.

During the rapid economic development, a large number of environmental pollutants are discharged, which will restrict the sustainable development of economy. In recent years, researches on EKC in China are mainly focused on the developed eastern and central areas. And there are few studies on the underdeveloped western China with fragile ecological environment, especially the Qinghai - Tibet Plateau with unique environment. Wu Yu-ping *et al.* have obtained significant inverted "U" curve in the research on pollution index of Beijing[1]. Zhang Xiao also has obtained inverted "U" curve with weak EKC between per capita SO_2 and per capita GDP according to the waste gas emission per capita[2]. Researches on Beijing, Tianjin, Shanghai, Hubei, Anhui, Shandong, Guandong, Ningxia and other cities and provinces in China indicate that relationship between economy and environment shows a "U + inverted U"-shaped curve or " inverted U + U"-shaped curve[1,3-9]. These studies have pointed out the relationship between the environmental condition and economic development in research region, having certain reference value for the policy making and the evaluation of local environment.

Taking Qinghai Province as an example, development law of economy and environment is discussed so as to provide reference for the harmonious development of environment and economy in Qinghai Province, as well as for the comprehensive evaluation of the relationship between economy and environment in Qinghai - Tibet Plateau.

1 Construction of the relation model between economic development level and environmental quality

1.1 Economy-environment condition of Qinghai Province

Qinghai Province is a typical western province located in Qinghai - Tibet Plateau, with the transition from Qinghai - Tibet Plateau to Loess Plateau in the eastern Qinghai Province. It is also the intersection part of three natural regions of the northwest arid area, the Qinghai - Tibet Plateau area and the eastern monsoon area with harsh natural condition and extremely fragile ecological environment. Economic strength of Qinghai Province is relatively weak. The per capita GDP ranks the last but ten in China in the year 2006, showing that Qinghai is at the middle stage of industrialization. Statistics show that GDP of Qinghai Province has increased from 3 844 billion yuan to 64 158 billion yuan from 1986 to 2006 and per capita GDP has risen from 916 yuan to 12 809 yuan. During this period, discharge of industrial waste water has declined from 84 million tons to 71.68 million tons; discharge of industrial waste gas has increased from 32.9 billion cubic meters to 209.9 billion cubic meters; discharge of industrial solid waste has risen from 8 950 thousand tons to 22 490 thousand tons; and discharge of indus-

Received: September 2, 2009 Accepted: September 20, 2009
* Corresponding author. E-mail: zhaoqinglin1067@126.com

trial SO_2 has increased from 38.7 thousand tons to 121.2 thousand tons. Therefore, it can be concluded that water pollution has been somewhat alleviated, but atmospheric environment and solid waste have shown the trend of marked deterioration.

1.2 Selection of data and index Annual discharge amounts of industrial waste water, exhaust gas, solid waste, and SO_2 are selected as the indices reflecting the environmental quality level of Qinghai Province. Data are from the 1997 – 2007 *Qinghai Statistical Yearbook* and *China Statistical Yearbook*.

1.3 Establishment of relation model The model used is the econometric model of economic development and environmental pollution established by a Chinese scholar Zhang Xiao based on the empirical data of China. The equation is[9]:

$$Y=\beta_0+\beta_1 x+\beta_2 x^2+\varepsilon, \quad (1)$$

where y is the pollutants emission or per capita emission, x is per capita GDP, β_0, β_1 and β_2 are model parameters, and ε is random error. Per capita GDP is taken as the X axis and the industrial "three wastes" emission and its per capita emission are taken as the Y axis. According to this model, fitting curve is predicted primarily by Excel and SPSS software system. Result shows that characteristics of inverted "U"-type EKC are insignificant and the fitting result is not idea.

Based on this, we believe that there may have certain complexity in the evolution process of economic growth and environmental pollution in Qinghai Province. And there are certain differences between fitting curve and traditional EKC. In order to better reflect this process and to absorb the latest research results, the following econometric model is used[7-8]:

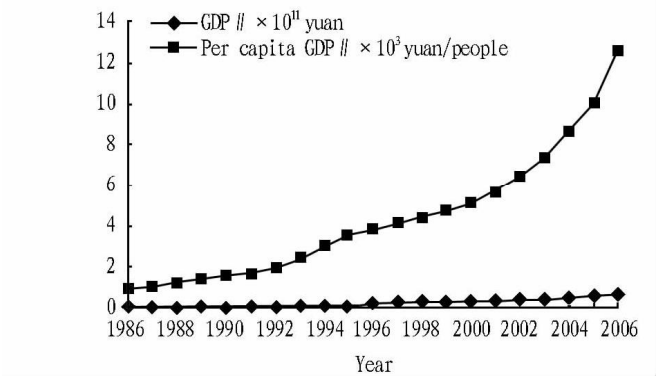
$$Y=\beta_0+\beta_1 x+\beta_2 x^2+\beta_3 x^3+\varepsilon. \quad (2)$$

2 Fitting result of per capita GDP and pollutants emission model

Table 1 reports the result of SPSS regression analysis according to equation (2). And Fig. 2 –5 illustrate the regression curves of per capita GDP and environmental quality indices.

Table 1 Simulation results of four EKC environmental indices in Qinghai Province

Environmental pollution index	Model coefficient			
	Constant term	β_1	β_2	β_3
Discharge amount of industrial waste water	8 920.231	−1.903	0.00	−6.20E-09
Discharge amount of industrial waste gas	340.971	−0.015	1.69E−005	−4.12E-10
Discharge amount of industrial SO_2	6.808	−0.003	5.55E−007	−2.10E-11
Discharge amount of industrial waste solid	163.486	−0.051	4.97E−006	−1.50E-10



Note: Data are from the 1987 –2007 *Qinghai Statistical Yearbook*.

Fig. 1 Growth trend of GDP per capita and GDP of Qinghai Province

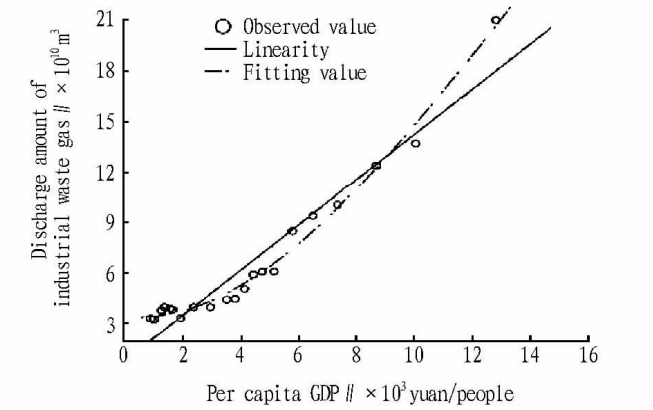


Fig. 3 Relation curve between per capita GDP and discharge amount of industrial waste gas

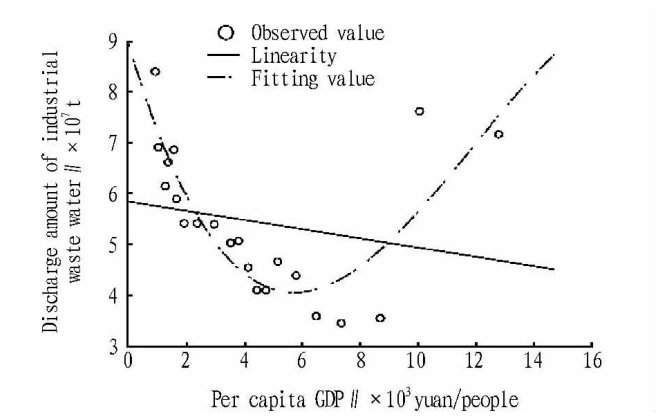


Fig. 2 Relation curve between per capita GDP and discharge amount of industrial waste water

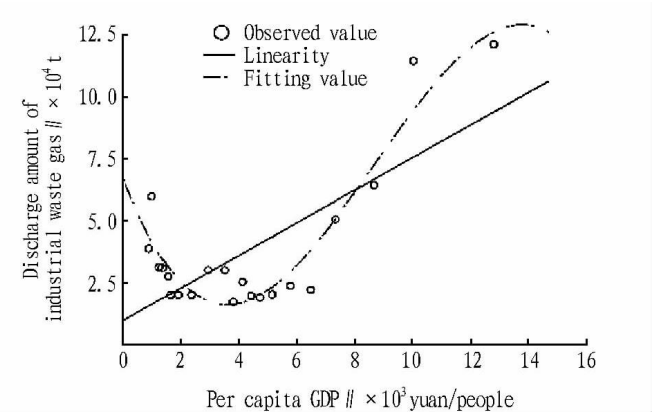


Fig. 4 Relation curve between per capita GDP and discharge amount of industrial SO_2

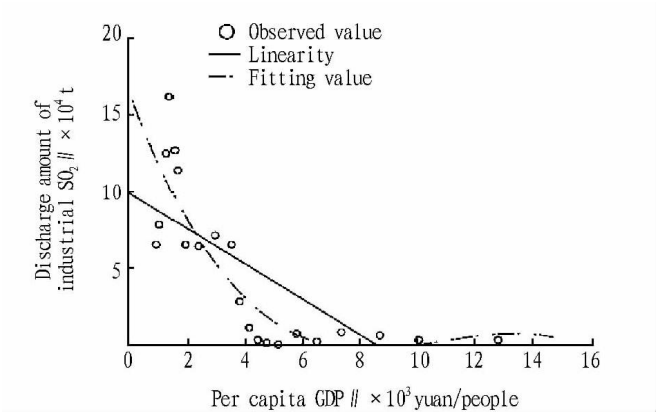


Fig. 5 Relation curve between per capita GDP and discharge amount of industrial solid waste

3 Result analysis

The curve of per capita GDP and the pollutants environment index has obtained relatively idea fitting result. Fitting goodness R^2 between per capita GDP and discharge amount of industrial waste water, waste gas, SO_2 and solid waste are 0.744, 0.987, 0.599 and 0.756, respectively. Among them, per capita industrial wastewater has the optimum fitting result (R^2 = 0.987), having relatively full explanation meaning to EKC; while fitting goodness between SO_2 discharge amount and per capita GDP is only 0.599, which does not accord with the classical theory of EKC. Relation curve between per capita discharge of industrial waste water and per capita GDP shows a positive "U" type, that between per capita discharge of industrial waste gas and per capita GDP can be regarded as the right part of weak "inverted U" shape, that between per capita SO_2 and per capita GDP shows the left part of "U + inverted U" shape, and that between per capita solid waste and per capita GDP shows a weak "U + inverted U" shape. Therefore, it can be seen that the relationship between economic development and environmental quality of Qinghai Province does not fully consistent with the inverted "U" -shaped curve.

Fitting result of Fig. 2 is basically in accordance with the wastewater pretreatment of Qinghai Province. However, degree of pollution has increased after the year 2004; and pollutants emission has started to rise. Economic development model with high consumption and high input in Qinghai Province has resulted in progressive deterioration of pollution. And Qinghai-Tibet Plateau region having fragile eco-environment needs a longer time to recovery. Fig. 3 and 4 show that waste gas and SO_2 emission develops simultaneously with the enlargement of urban industrial scale. Waste gas emission has reduced from 3 970 thousand tons in the year 1 989 to 3 310 thousand tons in 1992. Waste gas emission has increased sharply and SO_2 emission has shown an upward trend since the year 1995, which has certain relation with the input increase of economic development and resource utilization. Although industrial SO_2 emission in Qinghai Province has entered a transition period theoretically in the year 2005, this does not mean SO_2 pollution is already in a period of economic coordinated development. Fig. 5 indicates that discharge amount of industrial solid waste declines from 1986 to 2001, and then changes little from 2002 to 2006. Therefore, we can conclude that the environmental status of Qinghai Province is not optimistic. EKC points out that pollution degree would decline after economic development reaching a certain level. But it is obvious that the environment quality will not be improved, which is verified by the distinct differences between water and atmospheric pollution. Thus, environmental control by the government does have obtained a noticeable impact.

4 Conclusion and suggestion

4.1 Conclusion The following conclusions can be obtained through empirical study on Qinghai Province. Firstly, economic development of Qinghai Province does not fully consistent with the inverted "U" -shaped curve. As a province located in Qinghai-Tibet Plateau with fragile ecological environment and backward economy, Qinghai Province is significantly different from the developed regions of China. Per capita waste water shows a "U" -shaped curve; waste gas emission is at the accelerated increasing stage along with the growth of economy; and only SO_2 and waste solid discharges have declined in recent years. Secondly, positive environmental investment can hardly control the level of pollution. Though EKC indicates that economic growth will improve the environmental quality, it does not occur automatically with the increase of income. Factors improving the environmental quality are a series of major changes behind economic growth, which are income level, industrial economic structure, economic activity level and scale, environmental policy, technological level, environmental protection expenditure and environmental awareness of the public.

4.2 Suggestion

(1) Optimizing economic structure and reducing the level of resource consumption and environmental pollution. According to the fragile ecological environment of Qinghai Province, "high growth and high pollution" economic development model has caused serious damage to the ecological environment in Qinghai Province. Therefore, we should readjust the industrial structure, develop high-tech industries and tertiary industry represented by service industry, offer policy support for cycle industry, clean production enterprise and environment-friendly product, punish the environmental unfriendly products by reducing subsidies and improving taxes, stop introducing "high pollution and high energy" enterprises, enhance clean production of enterprises, promote the output and sale of environment-friendly product, reduce the pollution emissions by controlling contamination source, and seek the maximum benefit of economy-environment.

(2) Further adjusting the industrial structure and promoting the economic transformation from extensive type to intensive and environment-friendly type. Under the guidance of scientific development concept, we should make suitable development strategies, actively develop industry for the development of Qinghai – Tibet Plateau region, and improve resource utilization. Meanwhile, we should implement green economic plan, enhance clean energy and clean production, and actively promote the construction of ecological province.

(3) Increasing investment in environmental protection and speeding up the improvement of environmental quality. During the "Tenth Five-Year Plan", Qinghai Province has begun to fo-

cus on the control of atmospheric environment, has invested nearly seventy percent funds in the pollution control of sulfur dioxide control areas in Xining, Haidong and Golmud, and has set up Sewage Treatment Plants in Xining and other areas. In the year 2006, wastewater discharging rate of China reaches 90.7%, but that of Qinghai Province is only 49%, indicating that water pollution is hard to be alleviated, though treatment rate of pollutant is enhanced. Therefore, when increasing investment, government should actively introduce policies to encourage various economic components in Qinghai Province and the social funds of other provinces in order to invest in environmental protection project and industry.

(4) Actively developing the comprehensive value of industrial three wastes. At present, under the irrational economic structure and the lack of pollution control capital, there is broad prospect for the development of industrial three wastes. Waste residue, waste water (liquid), waste gas and waste heat should be recovered and rationally used during the production process of enterprises. Recycle of waste materials during the process of social production and consumption can greatly promote the utilization rate of resource. Solid waste has reached 1 515 410 thousand tons in the year 2006. Among them, comprehensive utilization amount is 926 010 thousand tons and the utilization rate is 60.2%. Output value of comprehensive utilization of three wastes is 102.7 billion yuan. Solid waste utilization of Qinghai Province is only 30.0% and the output value of comprehensive utilization of three wastes is 103 692 thousand yuan[10]. Therefore, improving utilization rate of industrial three wastes and realizing resource reuse is the only way to develop circular economy of Qinghai Province.

(5) Raising people's awareness of environmental protection. Environmental degradation has cumulative and amplifying impacts. We should not follow the old road of "treatment after pollution" due to the limited self-purification capacity of environment and the increasing input demand after being polluted. In other words, there is an environment "load threshold". And not all the environment pollution has the possibility to be improved.

5 Conclusion

During the process of western development, increase of economic scale and growth of pollutants will inevitably affect the environment of Qinghai Province, located in Qinghai – Tibet Plateau and having fragile ecological environment. How to balance the relationship between economic construction and ecological and environmental protection so as to realize the win-win situation is an issue that decision-makers should re-examine. Restricted by the short time period (from 1986 to 2006) and limited environmental quality indices, this research can not comphrehensively reflect the relationship between economic development level and environmental quality, which brings certain limitation to the analysis and evaluation.

References

[1] WU YP, DONG SC, SONG JF. Modeling economic growth and environmental degradation of Beijing [J]. Geographical Research, 2002, 21(2): 241 –246. (in Chinese).
[2] ZHANG X. The overall evaluation of Chinese environmental policy [J]. Social Sciences in China, 1999(3):88 –98. (in Chinese).
[3] WANG XQ, LI F. Econometric analysis of the relationship between economic growth and environmental degradation of Tianjin[J]. Geographical Research, 2005, 24(6): 834 –838. (in Chinese).
[4] YANG K, YE M, XU QX. Environmental Kuznets characteristics of municipal solid waste growth in Shanghai City[J]. Geographical Research, 2003, 22(1):60 –66. (in Chinese).
[5] CAI LJ, HUANG W. The relationship between economic growth and environmental pollution in Hubei Province [J]. Contemporary Finance & Economics, 2006(8):90 –93. (in Chinese).
[6] WU KY, CHEN XJ. Study on the relationship between economic growth and environmental degradation of Anhui Province [J]. Chongqing Environmental Science, 2003, 25(6): 9 –11. (in Chinese).
[7] XING XF, LIU YY. Measurement and analysis of the relationship between economic development and environmental protection of Shandong Province[J]. China Population Resources and Environment, 2006, 16(1):58 –61. (in Chinese).
[8] LIU L. The environmental Kuznets Curve of Guangdong Province [J]. Research of Environmental Sciences, 2005, 18(6):7 –11. (in Chinese).
[9] SHAO NP, LIU XP, QU XY. Characteristics of Kuznets Curve of Three Wastes discharge in Ningxia [J]. Resources & Industries, 2009, 11(1):105 –110. (in Chinese).
[10] National Bureau of Statistics of China. China statistical yearbook (2007)[M]. Beijing:China Statistics Press, 2007. (in Chinese).

青海省经济发展水平与环境质量关系研究

赵青林[1],毛 伟[2],彭 瑛[3] (1. **青海师范大学生命与地理科学学院**,**青海西宁** 810008;2. **中国地质大学研究生院**,**湖北武汉** 430074;3. **湖南工业职业技术学院**,**湖南长沙** 410208)

摘要 本文选取了青海省1986 –2006 年的经济与环境数据,以环境库兹涅茨曲线(EKC)理论为基础,采用 SPSS 软件建立了人均 GDP 与人均污染物排放量的模型,对青海省经济发展水平与环境质量进行了模拟。研究表明,青海省经济 – 环境关系不完全符合环境库兹涅茨曲线倒 U 型特征,呈现显著三次曲线特点:工业废水为正"U"型,废气表现为 U 曲线的右半部分,SO_2 与固体废弃物则呈正"U + 弱倒 U"型曲线。青海省水环境和大气环境污染进一步恶化,SO_2 与固体废弃物近年出现弱转折点,近年有下降趋势。为使环境质量得到改善,需优化经济结构,调整产业结构,加大环保投入,积极开发工业三废的综合利用价值以及提高全民环保意识。

关键词 环境库兹涅茨曲线;经济发展;环境质量;青海省