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SUSTAINABLE DEVELOPMENT OF THE SERIOUSLY POLLUTED CITIES IN CHINA ——Taking Benxi City as an Example

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ABSTRACT: The environmental problems in the seriously polluted cities in China have been paid attention to by policy-makers and foreign and domestic scholars. However, it is very difficult to improve the environmental quality fundamentally due to its complexity, for example the formation of the seriously deteriorated environment. It is considered that the terminal harnessing is an important way, but the spread of high-level terminal treatment is restricted by the limit of funds and technological level. Therefore, the way for a sustainable development of the seriously polluted cities should be multiple-sided, which is to correlate the operation of environmental protection with the operation of city construction. To achieve an identity of these opposites, measures should be taken during economic development and environmental protection in every developing stage. In this paper, the authors take Benxi City as a case study.

KEY WORDS: sustainable development, seriously polluted city, urban environment, environmental pollution, Benxi City in China

I. INTRODUCTION

Cities are the symbols of human's civilization, the spatial carriers of economy and the sources of regional economic activities(Gu, 1994). Whereas they are the districts where human's activities remake nature most strongly and nearly all the results of human's behaviors on socio-economy can be found, in which the environmental pollution is the most direct and most serious one(RCSDCPU, 1994). Although all the big and medium-sized cities in China have the problems of environmental pollution in different levels, with the low environmental standard and the low developing intensity in developing countries, there are not many so-called seriously polluted cities in China, among them Benxi City in Liaoning Province is a typical one. Benxi was a mountainous city with beautiful scenery originally, but to the middle term of the 1980s, the pollution was quite serious and the city was called "the only invisible Chinese city from

satellite". The national government has paid much attention to the environmental harnessing for this kind of cities. From 1987 to 1992, the investment of the engineering for pollution's treatment on water, atmosphere and solid waste came up to 312.7 million yuan(RMB) only in Benxi City, and the result was marked.

The formation of environmental problems in seriously polluted cities is multiple-sided and multiple-hierarchy. So it can't be resolved thoroughly by only depending on terminal harnessing. Many problems such as the short of funds, the low level of the technology for harnessing and the high expenditure also restrict the resolution. Based on these factors, the only way is to realize sustainable development in these seriously polluted cities. To get to this goal, the meanings and technical ways should be 3-dimensioned with multiple hierarchy. The measures of engineering harnessing can't be replaced, but they are not all-powerful, so we should find a way for sustainable development in seriously polluted cities from higher hierarchy.

II. PRESENT CHARACTERISTICS OF URBAN ECOLOGICAL ENVIRONMENT IN BENXI CITY

1. Characteristics of Environmental Pollution

1.1 Air pollution

Air pollution is one of the most seriously environmental problems in Benxi. Because of too much SO_2, TSP, CO and NO_X in urban atmosphere, Benxi City became "the only invisible Chinese city from satellite". the atmospheric environment can be seen from the monitoring results in every functional areas in 1992. (Table 1).

Table 1 The air pollutant concentration and over-standard times in functional areas of Benxi City

		Industrial district	Residential district	Traffic district	Cleaning district
Concentration	SO_2(mg/m^3)	0.18	0.17	0.16	0.15
	TSP(mg/m^3)	0.48	0.38	0.62	0.24
	Dustfall (t/mon·km^2)	58.00	30.20	60.00	21.80
Over-standard times	SO_2	2.0	1.8	1.7	1.5
	TSP	0.6	0.3	1.1	–
	Dustfall	6.2	2.8	6.5	1.7

1.2 Water pollution

The Taizi River is the only surface stream that flows through the city proper. The waste water had got to 2.38×10^8 tons, among which the industrial waste water had got to $1.84\times$

10^8 tons (according to the data of 1990). More seriously, more than half of the waste water was not disposed, so the Taizi River is seriously polluted in Benxi section. The monitoring data show that the concentration of BOD_5 was 14.00 mg/L, the oil concentration was 8.72 mg/L, COD concentration was 38.29 mg/L. They were 3.5 times, 16 times and more than 2 times respectively as high as the surface water quality of the 3-hierarchy standard.

1.3 Noise pollution

Benxi is located in the southeast of Liaoning Province, which is an industrial city whose main industries are steel industry, coal industry and building materials. The special topography——river valley's basin restricts the traffic development, which has a bad influence on the background of noise in Benxi City. With a disordered urban distribution and an inter-influence of the functional areas, the noise has seriously influenced the residents, among the factors of noise the industrial noise and the noise of urban transportation are the most serious. In the city proper many monitoring stations are over standard more than 20%, especially during the night some places are over standard even more than 50% (Table 2).

Table 2 The equivalent continuous A-weighted sound level in 3 main functional districts of Benxi in autumn (dB(A))

	Residential district				Business quarter		Industrial district	
	Xinlitun	Zhuanshan	Dongming	Caitun	Nandi	Xihu	Cement Plant	First Iron Factory
1991	43.3	49.5	55.4	53.9	66.4	69.8	62.0	71.5
1992	42.7	49.9	55.6	53.8	68.4	71.1	61.8	71.7
1993	47.0	60.2	58.9	62.0	69.4	62.2	64.3	62.1

1.4 Solid waste

Special industrial structure leads to the industrial waste in Benxi City mainly from smelting dust, coal cash, tailings and slag, etc. During the 5 years from 1986 to 1990, the industrial solid waste got to 6.357×10^4 tons, in 1990 the store in whole city was 1.7×10^8 tons, which occupied land of 880×10^4 m^2 (Table 3). The whole city's yield of trash every year is between 30.1×10^4 and 33.9×10^4 tons, in 1990 it was 32.8×10^4 tons. Every year the solid waste that residents in Benxi have to bear is 11.8 tons per person, which is dramatically higher than the average of the large and medium-sized cities in the eastern China.

Table 3 The discharge amounts of industrial solid waste in Benxi City from 1986 to 1990(10^4t)

Years	Disposed	Indisposed	Used	Discharge	Total	Accumulative
1986	30.90	961.30	203.06	68.10	1263	11728
1987	37.00	976.00	204.00	27.00	1244	12552
1988	18.00	1000.00	219.00	38.90	1275	15074
1989	12.00	1018.00	220.00	35.37	1285	16127
1990	15.00	1019.00	231.07	32.03	1297	17178

2. Characteristics of Urban Land Use

Land is the bearing body of urban production and life, the conditions of landuse (such as structure, intensity and effect) indicate the basic characteristic of urban ecological environment.

2.1 Structure of landuse

Based on the result of the aerial photography's interpretation, through the revision of urban planning data, we got the equilibrium of landuse in built districts in Benxi City (Table 4).

Table 4 The equilibrium of landuse in built districts in Benxi City

	Residence	Public	Industry	Store	Traffic	Road	Greenery	Others	Total
Area(ha)	1598.60	315.79	1343.50	172.80	191.50	158.60	113.04	82.16	3968.70
Percentage	40.10	8.00	33.80	4.40	4.80	4.00	2.80	2.10	100.00
Land per capita (m^2)	24.84	4.91	20.88	2.69	2.98	2.46	1.76	1.28	61.67

Comparing the data of Table 4 with national standard, we found out that the proportion of residential land was about 10.1% higher than the upper limit, the industrial land was 8.8% higher than the upper limit, while the proportion of green surface and the urban land were about 5.2% and 4% lower than the national standard respectively. This shows that population and industrial firms in Benxi was over standard, and the intensity of landuse was high.

2.2 Intensity of urban landuse

Comparing the intensive coefficient of urban landuse in 11 cities whose population were between 700 and 900 thousand, the coefficient in Benxi was only less than Datong City in Shanxi Province. The constructive land in the city proper in Benxi City was about 61.67 m^2 per person, which was close to the lower limit of grade I.

3. Quality of Residential Life Environment

Quality of life environment is a main component of quality of urban residential life(RCSDCPU, 1994). The questionnaire showed that the environmental pollution in the residential district and the industrial district was serious, among the pollutants, dust, noise and dustfall were the top three that influenced the residential life greatly. Residents in Benxi felt that the threat of environmental pollution in Benxi was far higher than that in other cities(Table 5). This indicates that environmental pollution has threatened the quality of residential life in Benxi City.

4. Characteristics of Urban Ecology

Percentage of urban greenery coverage is an important index that indicates the ecological

Table 5 The comparison of the people's feeling about the pollution among 4 cities in China

	Beijing		Xi'an		Yangzhou		Benxi	
	Number	%	Number	%	Number	%	Number	%
Dirty air	113	20.6	123	24.6	32	6.3	334	82.3
Noisy and dirty residence	150	27.3	143	28.5	63	12.3	306	75.3
Harmful working environment	62	29.6	153	37.3	85	21.5	269	77.1

quality. According to statistics, in the city proper the public green surface per person is 2.15 m^2, which is lower than the average level of cities in China——4 m^2. The percentage of green surface is 3.17%, which is lower than the average level of cities in China——11%, and the distribution of green surface is unbalanced, most of it is located in the outshirt of the city where is far from the residential district, so its ecological effect is not obvious.

III. STRATEGIES ON SUSTAINABLE DEVELOPMENT IN SERIOUSLY POLLUTED CITIES

1. Sustainable Development, the Only Way for Seriously Polluted Cities

According to the research, for old seriously polluted industrial cities like Benxi City, the only way to develop economy, improve environment and quality of social life is to realize sustainable development(Mao, 1995) and a good relationship between economic development and environmental protection. So we must go on with the environmental harnessing from multiple sides and multiple hierarchies based on resolving the environmental problems during the process of socio-economic development. The way that one wants to resolve the environmental problems by weakening or even stopping economic development is out of the question.

2. Macro-strategies

2.1 Adjusting the industrial structure

Seriously polluted cities generally came into being as old industrial base, so its economic structure is simple. The industry of Benxi City belongs to the type of mineral resources, its principal part of industry is metallurgical industry, while the main industries are metallurgical industry, the chemical industry and the building material, which has a high input (output) of material and energy that needs a large number of fund, but the fund's return is slow, the products' extra income is low and the economy is influenced by the market's fluctuation greatly. This kind of industrial developing pattern and economic structure that formed under the long-term planned economy is irrational, but it is difficult to renew thoroughly. Based on this, we think that the industrial structure of Benxi City should be guided to a new strategy with four directions, which is also the common reform direction of other old industrial bases and seriously

polluted cities:

(1) Diversification of industry: Enlarging the proportion of the tertiary industry and cutting down the proportion of the second industry will avoid the emergence of economic fluctuation. Benxi Steel Firm takes an important role in Benxi economy, so to realize a multiple production of Benxi Steel Firm is an important way to enrich the diversity of the industrial structure in Benxi. It is better to develop a multiple-management based on Benxi Steel Firm than that only based on administrative meanings by the government.

(2) Light industry: Transforming from heavy industry to light industry, enlarging the proportion of light industry.

(3) Seriation: Based on the processing degree we classify the industrial branch from low grade to high grade, which is mining branch → elementary processing branch → senior processing branch → high → technology branch, and the effect is from low to high. Most industrial branches in Benxi belong to elementary processing branch, so either from the angle of economy or from the angle of ecological environment, the industrial structure of Benxi City should be developed to senior processing and seriation.

(4) High grade: According to the principle connecting high-technology with resources, we choose new industrial increasing point. For example, in Benxi we can develop medicine-making industry, electronic industry and facilities for communication, manufacturing industry and industry of environmental protection, etc. (Cui *et al.*, 1994; Cui, 1995).

2.2 Choosing a rational urban-economic developing pattern

(1) Urban developing pattern: Restricted by topography and influenced by historical development, the population in Benxi City increased quickly and had given a great pressure on urban land. For the ongoing development and enlargement of the city, there are three ways: the first one is around the city in the near future; the second one, in a long-term, the satellite towns should be built; the third one, in a limited space, some specialized functional districts should be constructed, just like in Huolianzhai the main developing direction is the industry for store and building material, in Beitai the main developing direction is iron and steel industry, in Qiaotou the main direction is cooperating the industry in Beitai and the marshalling yard and in Shiqiaozi the developing zone for new industry should be developed.

(2) Keeping eyes on the big and medium-sized firms: Based on the condition of industrial structure of Benxi, the key of industrial organization should be the reform on technology and the managing system of big and medium-sized firms, meanwhile we should construct group of big-sized firms. Here, we must emphasize that town and township firms are not the keys to develop economy in Benxi because of the contradiction between land demand and supply, meanwhile the condition of environmental quality is not very good, so the town and township firms can't be distributed everywhere.

2.3 Resolving environmental problems based on economic development

In seriously polluted cities economic development can not be restricted or stopped for harnessing of pollution, and the old road that "harnessing after development" is not available. En-

vironmental problems should be resolved during the economic development. The material waste should be cut down as well as the weight of seriously polluted industry, and the intensity of environmental control should be enlarged, only through this way can economic development and environmental protection be compatible.

3. Medium-strategies

3.1 Adjusting the industrial distribution and optimizing the structure of landuse

Through formulating right policies for industrial development (such as investing to the tertiary industry and inclining to new zones) and establishing land market by the means of land price, the goal of adjustment on the distribution of urban industries can be realized.

The ways to reform the old proper of Benxi City include the following steps:

(1) Improving the urban traffic structure and widen the main road.

(2) Building an ecological corridor along the Taizi River, afforesting the unused land and most of the new-increased land after straightening the Taizi River, meanwhile constructing garden on the good-conditioned section.

(3) Controlling the intensity of landuse rationally.

(4) Improving the functional areas, gradually adjusting the dispersed mineral factories and settlements, incorporating them into the industrial districts and residential districts that have good service facilities and good cooperating conditions.

(5) Medium-sized or little firms should be taken away gradually, while the tertiary industry, the settlements and public-used land should be increased.

3.2 Rationally using water resource

(1) Through the reform of technology, to cut down the use of water per product or per output value.

(2) To improve water's repeatedly-used index through replacing humid dust removal by dry dust removal, splitting waste flow and using cooling water repeatedly.

(3) To realize waste water reuse through establishing sewage treatment plants or other sewage-reused technology.

(4) To build shelter-forest for water resource, through restricting little mineral factories production, managing the sloping field rigidly, and constructing a forest-fruit-medicinal materials-mushroom ecological system, guarantee the quality and area of the shelter-forest.

4. Micro-strategies

4.1 Construction of green ecological project

The green ecological project includes the following items: greenery project of road; greenery project of firms; greenery project of residential districts; greenery project of isolated belt; project of garden and environmental forest garden. According to the characteristics of small re-

gion, dense population and over-intensified industry, eight scenery districts, twelve gardens for sightseeing, eight main roads and shelter-forest were designed in Benxi City, with the landscape of forest and geomorphology as the main body, connecting the city with green surface, the green surface function on environmental protection will be brought into play and the quality of residential life will be improved(Cui, 1995).

4.2 Intensifying the harnessing of pollution

(1) The investment of pollution harnessing should be ensured, while the aid and loan supported by international organizations of environmental protection should be striven for. Within the region the proportion of investment on environmental protection should be 10% – 15% of GNP(Gross National Products), and the proportion of investment on environmental protection in the construction of infrastructure and the fee for technological reform should be used fully. The effect of fund use should be improved, while the construction of environmental protection system itself during the investment on environmental protection should be intensified suitably, especially on the input of environmental research, management and technological equipment.

(2) The production technology should be reformed and the harnessing technology should be drawn, which should include technologies of dust removal and desulfurization, the treatment of water pollution and the reuse of solid waste, etc.

The concrete strategies on the harnessing of pollution are as follows:

- To put new equipment such as new dust machines on dust collection into use;
- To go on developing heat and power plants, enlarging the area of intensified heat supply, developing urban coal gas and popularizing the coal for industrial use;
- To intensify the treatment of sewage, to establish the sewage treatment plants;
- To popularize sewage interception project;
- To spread the project on disposition and reuse of domestic refuse and industrial solid waste;

4.3 Scientifically environmental management

(1) Responsibility system and the law implementation should be intensified.

(2) Environmental protection market and land market such as water resource market, market of exchange on the right of pollutants discharge should be established.

(3) Monitoring system and warning system should be strengthened.

(4) Environmental education should be popularized, while ideas on environmental resources and responsibility of environmental protection should be established.

(5) Currently management system in effect should be perfected and the managers' quality on professional work should be improved.

IV. CONCLUSION

The only way that can be realized on the economic development and the environmental improvement in seriously polluted cities is to strive for a sustainable development, and the way is

multiple-sided with multiple hierarchy. Every branch and every link of urban and economic construction should be connected with environmental protection, and the environmental problems should be resolved based on the process of economic development. Only through this way can the seriously polluted cities in China such as Benxi City be the ones with beautiful environment and flouring economy.

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