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Environmental influence of Wuhan urban agglomeration development and strategies of environmental protection

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Abstract: In Wuhan urban agglomeration (WUA), the population growth and concentration, the industrial development and urban sprawl have been affecting the environment fundamentally. Comparing with Yangtze delta metropolitan region, the level of urbanization and industrialization of WUA has lagged behind for about 10 years; but the problems in environmental protection and rehabilitation are commonly serious. In the future, WUA should avoid unnecessary mistakes and seek a win-win strategy for economy and environment in its large-scale development stage. Based on the analysis of the changing of main environmental pollutants and the coupled curves in past decades, the paper discussed the important links among the urban environmental pollutions, industry growth and urban sprawl in WUA. It is concluded that the integration of economic and environmental policies in urban development is more required and significant at the large urban agglomeration region. Four proactive and long-term strategies need to be adopted to provide prior guidance and better protection for the development of WUA.

Keywords: environmental problem; urban development; Wuhan urban agglomeration; strategies

Introduction

Urbanization is one of overwhelming trends in China, causing population concentration and construction expansion in the urban areas. Urbanization and industrialization are inseparably interconnected. As large natural resources consumers as industries, the cities are also major generators of trans-boundary pollution and waste (Li and Xue, 2000; Capello and Faggian, 2002), and the environmental pollution becomes a by-product of urbanization and industrialization. The more rapid industrial growth and urban sprawl may lead to more rapid depletion of natural resources and more rapid production of polluting wastes (Baumgärtner *et al.*, 2002; Hu, 1994; Wu *et al.*, 1998). Furthermore, the pollutants caused by industrial growth and urbanization may accumulate in the natural environment and produce negative side-effects over time (Nijkamp, 1999; Baumgärtner *et al.*, 2002).

The increasing severe consequences of environmental problems in recent years have led to an increasing awareness that the urban and industrial development have to be sustainable (Huang *et al.*, 1998). For this reason, it is important to study the aggravating environmental damage associated with urban and industrial growth (McCarthy, 1999). The data announced by the State Environmental Protection Administration indicate that there are significant links between the environmental problems and the urbanization performance in China (http://www.sepa.gov.cn/eic//20050602/8240.shtml). However, the links undoubtedly have not been fully understood yet. The aims of this paper are to study by empirical analyses whether urban sprawl and economic activities are associated with some specific environmental and ecological costs in the metropolitan area of Wuhan urban agglomeration (WUA), and bring forward four strategies that WUA should take. The study is grounded on the analysis of monitoring data, literature and field survey in WUA.

1 Study area

1.1 Wuhan urban agglomeration (WUA)

Wuhan is the capital of Hubei Province and one of the major industrial centers in the central of China. In the 100 km distance around it, there are eight cities, including Huangshi, Ezhou, Xiaogan, Huanggang, Xianning, Xiantao, Qianjiang and Tianmen. The nine cities (Fig.1) are located in the east of Hubei Province (112°29′-115°14′E and 29°02′-31°35′N), covering an area of 5.8×10^4 km^2, and supporting 3049×10^4 population. This area occupies 33% of the land in Hubei, but accommodates over 50% of the population, and contributes 60% of Gross Domestic Product (GDP), 53% of the revenue, about 60% of the investment and 61% of the total volume of social retail sales in this province (Hubei Statistical Bureau, 2003). The embryonic form of a metropolitan agglomeration has emerged. Its GDP increased from 87.04×10^8 to 3291.38×10^8 RMB Yuan and subsequently its urbanization level increased from 18.21% to 34.36% during the past twenty-five years. The average annual growths of GDP and urbanization are around 16% and 2.57%. The paces of growths exceed the national average growths of 9.40% and 1.94% respectively. The areas of water and wetlands occupy over 10% of the land in WUA, which is the superiority and a distinguishing feature among other urban agglomerations. However, the continuing economic

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growth, the population increase and the rapid urbanization have not only caused the deterioration of water quality in many rivers and lakes but also exerted great pressure on the whole environmental system of WUA in recent decades.

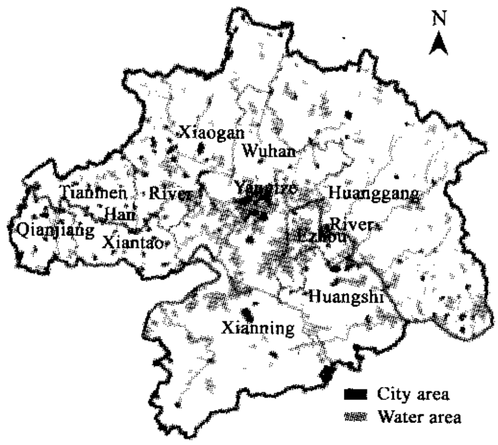

Fig.1 Water systems and scope of Wuhan urban circle

1.2 Comparison with other urban agglomerations

The economic development level of WUA is less than other urban agglomerations in Yangtze delta, Pearl River and Beijing-Tianjin-Hebei province region (Liu, 2004). The data in Table 1 indicate that the socio-economical level of WUA is much less than the metropolitan agglomeration in Yangtze delta (including 16 cities). The level of urbanization and industrialization of WUA lagged behind for about 10 years. However, it also suffers from a common environmental worries faced by many large urban agglomerations and there are common lessons to be learned (Button, 2002). Yangtze delta metropolitan region (YDMR) has paid an expensive environmental cost when it gains its economic benefit. A lot of literature have discussed the environmental problems in Yangtze delta, Pearl River and Beijing-Tianjin-Hebei region (Chen *et al.*, 2001; Yang, 1999; Bai *et al.*, 2003; Wang *et al.*, 2003; Yin *et al.*, 2005.). From the mid-term of 1990s, following the fast economic bloom and the urban sprawl, the pollutants discharge rose rapidly and the environmental quality drastically deteriorates (Qian *et al.*, 2002).

Comparing with Yangtze delta, Pearl River and Beijing-Tianjin-Hebei region, the environmental situation of WUA is passably better. Therefore, when the urbanization and industrialization of WUA enter a high-speed growth phase as that of YDMR did, how to mitigate environmental impact without causing delay to economic development is the question faced by urban managers of the cites (Wu *et al.*, 1998). WUA should avoid unnecessary mistakes and seek a win-win strategy for economy and environment in future large-scale development stage. The most important lesson from other urban agglomerations is that the sustainable urban policy must be adopted to reconcile the contradiction of the environmental protection and the economic development step by step in WUA (Table 1).

WUA will accelerate the industrialization and the urbanization under the guiding of the governments and the cooperation among cities. On one hand this acceleration will bring the growth of contaminant in quantity and types, and on the other the cooperation will be helpful to prevent the regionally environmental hazard. The role of government in urbanization of WUA is to promote cooperation and control the growth of contaminant.

Table 1 Comparison of WUA and YDMR (2002)

Items	Area, 10^4 km^2	Population, million people	Density of population, people/km^2	GDP per capita, RMB Yuan	Gross industrial output value,10^8 RMB Yuan	Urbanization rate, %
WUA	5.78	30.7	531	9694	2128.4	31.46
YDMR	10.02	75.7	755	25263	27037.08	42.96

Notes: WUA. Wuhan urban agglomeration; YDMR. Yangtze delta metropolitan region

2 Problems and coupling curves of WUA development and environment

Urban environmental problems have been divided into two different categories (Myllylä and Kuvaja, 2005): one is the problems relating to industrialization, such as uncontrolled emissions from factories and transportation; the other one focuses on the impact of waste generated by those who live and work in the cities. In this section, the environmental problems generated from industrial development and urbanization are discussed and the coupled relationship between them.

2.1 Environmental problems

The environmental pollution is gradually intensifying and it is directly relevant to urban sprawl and industry development. There are only 11 sewage treatment plants and 22 garbage treatment plants serving for thirty millions of populations. The construction of infrastructures lags behind the industrialization and urbanization greatly. The insufficient of infrastructures is one of the main reasons resulting in the poor environmental quality in WUA. In this sector, the spatial and temporal patterns of pollutions in the last decades were revealed by the statistics data (the statistic data of environment are from the reports of Hubei environmental quality over the years if no special explain) and the field investigation.

2.1.1 Water pollution

Major waterways in WUA are overburdened with sewage demands. In 2003, the total of wastewater effluent was 1452.35 million tons among which industries in WUA generated 43.19% and untreated domestic wastewater constituted 56.81%.

The water qualities of two large rivers, Yangtze River and Hanjiang River, are still good. Generally, the grade of water quality is Class Ⅱ. The eutrophication is infrequence in rivers. However, the algal bloom has appeared in Hanjiang River in recent years. For instance, algal bloom lasted from the middle February to end of March in down reach of Han River in 2000. In Xingou section, the peak quantity of algae was high to 4×10^7 pcs/L. The overload of TP might be the direct cause.

Most of tributaries have been polluted very seriously, such as Fuhe, Huanshui, Lushui, Fushui and Tianmenhe. The grades of these tributaries are between Class III and lower than Class Ⅳ. The main pollutants are ammonia nitrogen, COD (chemical oxygen demand), BOD_5 (Biochemical Oxygen Demand), nitrite nitrogen and volatile hydroxybenzene. For example, Fuhe, a tributary of Yangtze River, receives the industrial sewage and untreated living sewage mainly from Wuhan and Xiaogan. Except for the common pollutants, there are serious chloride and petroleum pollution so that Fuhe has become inferior Class V waterbody, almost a "billabong". This is caused by the large-scale industries of salt mining, chemistry and papermaking. The polluted river water is unqualified for drinking, irrigation and fishery.

The grades of some bigger lakes, such as Liangzihu, Dayehu, Baoanhu, Tangxunhu, Houguanhu and Futouhu, are Class III or IV. They are at the middle level of eutrophication and their TP (total of P) and TN (total of N) are above the national pollutant criterions. Since 1980s, the rivers and lakes in built-up area, such as Donghu, Moshuihu, Cihu, Qinshanhu and Yanglanhu, have become black-colored and odoriferous because of the infusing of a large quantity of untreated living and industrial wastewater. The grades of them are lower than Class V. The pollution degree has obviously exceeded the natural assimilating capacity of water bodies.

This study uses the composite index of water pollution to evaluate the water quality of lakes in built-up area of WUA (Fig.2). Its mathematical expression is:

$$PJ=\sum_{j=1}^{m}P_j/m;\quad P_j=\sum_{i=1}^{n}P_{ij};\quad P_{ij}=C_{ij}/C_{i0} \qquad (1)$$

where, PJ is the average composite index in j section; P_j is the composite index in j section; P_{ij} is the composite index of i item pollutants in j section; C_{ij} is the annual average value of pollutant i in j section; C_{i0} is the standard value of pollutant i; n is the number of items; m is the number of sections.

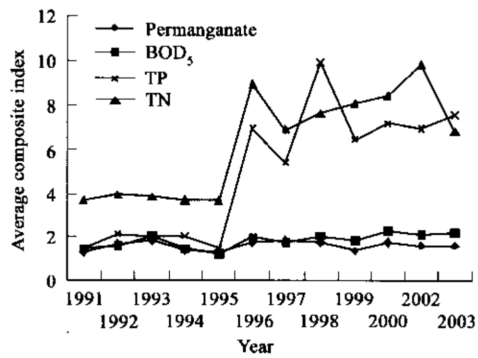

Fig.2 Trend of permanganate index, BOD_5, TN and TP of lakes in built-up area of WUA

The time series data indicated that the indices of TN and TP are much higher than that of BOD_5 and permanganate, and they increase gradually from 1991 to 2003. They are the main drivers which accelerate the procedure of the lake eutrophication in urban areas.

The pollutants in the surface water of WUA originate from industrial waste, municipal sewage, dejecta of livestock and poultry, chemical fertilizers, and so on. Organic pollution is by far the most serious one, and 56.81% of it comes from domestic sewage. Only 13% of sewage receives secondary treatment in sewage plants, 20% of sewage is treatment in simple facilities and the rest 67% raw sewage is discharged into rivers and lakes directly. There are no enough infrastructures for sewage collection and treatment in most area of WUA. Additionally, because of the density increase of towns and the distance decrease between them, the raw sewage flows to the water catchments of the next town without enough time to finish the self-purification. Most cities and towns use the water polluted by other ones in upstream areas. In the meantime, they drain the sewage to downriver towns. Therefore, although the industrial drainages are controlled, the water quality is continuing worsen because of the low treatment ratio of living sewage and those non-point sources.

Non-point pollution sources are paid more attention now. Fig.3 indicates the trend of increasing pesticide, mulch film and chemical fertilizer in agricultural production of Huangshi from 1991—2000. The increased dosage of chemical fertilizer, the shift of livestock and poultry breeding from scattered to highly concentrated and the increase of aquafarms will also lead to the larger contributions of N and P to water bodies, if effective measures are not taken in future years. Moreover, the pollution of heavy metals in urban soil is dramatically induced by sewage irrigation and pesticide, mulch film and chemical fertilizer in WUA. For instance, in Sanlihu irrigated area of Huangshi, the Cd (cadmium), Cu (copper) and Zn(zinc) pollution in soil is so serious that they caused the pollution of grain and greenstuffs.

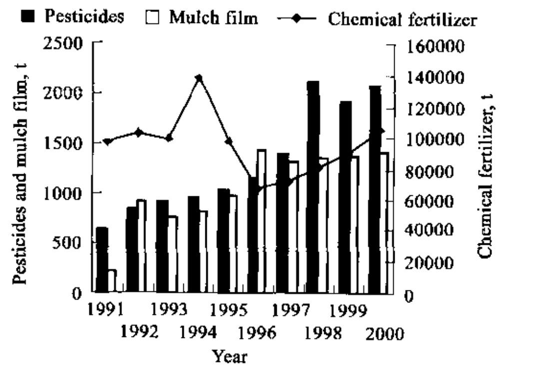

Fig.3 The increase trend of non-point pollutants in Huangshi from 1991—2000

2.1.2 Atmospheric pollution

Energy conversion processes place a considerable pressure on the air environment, and contribute to climate change, damage of natural ecosystems, and adversely effect human health (Balocco *et al.*, 2004). The composite index of atmospheric pollution is used for evaluating the atmospheric quality and its distribution regularity in 2003 (Fig.4). Its mathematical expression is:

$$P = \sum_{i=1}^{n} P_i; \quad P_i = C_i / C_{i0} \tag{2}$$

where, P is the composite index of atmospheric pollution; P_i is the composite index of pollutant i; C_i is the annual average value of pollutant i; C_{i0} is the standard value of pollutant i; n is the number of pollutants.

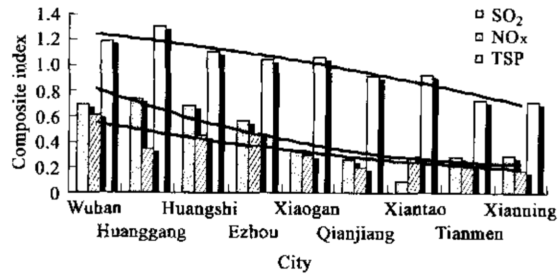

Fig.4 Atmospheric quality and distribution regularity in 2003

TSP (total suspend particle), SO_2 and NO_x are the key factors for atmospheric pollution in WUA. TSP is the chief pollutant which originated from coal-fired smoke, industrial stive, building sites; vehicle and bare ground raise dust. SO_2 is inferior to TSP. Due to the asymmetrical distribution of urban and industrial activities, the air quality of Wuhan, Huangshi, Ezhou, Huanggang and Xiaogan is relatively poor. Both industrial pollution and traffic pollution are equally heavy and the atmospheric pollution is gradually aggravated from urban periphery to core. The highest values of TSP, SO_2 and NO_x always appeared in the industrial areas and the heavy traffic areas. The air quality of Xianning, Xiantao, Qianjiang and Tianmen are good. The large proportion and the high energy consumption of heavy industries can explain this phenomenon in WUA. Since developing the heavy industries will still be the major idea in the next decade, SO_2 and TSP will still be main pollutants.

This study uses spearman correlation coefficient of atmospheric pollutants to evaluate the change of SO_2, NO_x and TSP from 1986 to 2003 (Table 2). Its mathematical expression is:

Table 2 Spearman correlation coefficient (r_s) of SO_2, NO_x and TSP from 1986 to 2003

Pollutant	Wuhan	Huangshi	Ezhou	Xiaogan	Huanggang	Xianning	Xiantao	Qianjiang	Tianmen
SO_2	0.555	-0.297	-0.203	0.477	0.287	0.089	-0.124	0.524	—
NO_x	0.483	0.499	0.713	0.152	0.516	0.175	0.421	0.275	—
TSP	0.348	0.181	-0.098	-0.390	-1.339	-0.889	-0.112	-0.342	—
Sample number	18	18	18	18	12	15	16	18	3

$$r_s = 1 - \left[6 \times \sum_{i=1}^{N} d_i^2 \right] / [N^3 - N]; \quad d_i = x_i - y_i \tag{3}$$

where, d_i is the difference between variables x_i and y_i; x_i is the sequence number of pollutants concentration in ascending order; y_i is the sequence number in time order; and N is the number of samples. Due to the lack of monitoring data, Tianmen could be not evaluated. When N=18 (from 1986 to 2003), $r_{s0.05}$=0.472. The results reveal that SO_2 pollutions of Wuhan, Xiaogan and Qianjiang went up markedly, while that of Huangshi, Ezhou, Huanggang, Xianning and Xiantao kept stable. All cities have the ascending tendency of NO_x pollution, among which the tendency of Wuhan, Huangshi, Ezhou and Huanggang are marked. TSP pollutions of Huanggang and Xianning are obviously at descending tendency and that of other cities have no obvious change. The raise of NO_x concentration shows that the increasing number of vehicles is gradually becoming the important cause of the degradation of air quality in cities. Especially in Wuhan, the load ratio of NO_x exceeds other cities obviously influenced by vehicle exhaust.

2.1.3 Living solid waste pollution

The disposal of solid wastes also needs to be paid an urgent attention. Solid waste is from industries, mining, living, building and farming with the rapid urbanization and population growth. The quantity of living solid waste is closely related with population, living standard, life style and consumption pattern. The data in Table 3 present that the speed of waste increase is accelerating. From 1995 to 2000, it increased at the average speed of 0.084 $\times 10^6$ t/a. From 2000 to 2003, the average speed became 0.37$\times 10^6$ t/a. In 1995, the waster discarded by each person per day is 1.06 kg, but in 2003, the quantity is 1.26 kg.

Table 3 Trend of living solid waste increased from 1995 to 2003

Year	Town population, $\times 10^6$	Living solid waste, $\times 10^6$ t	Average per day, 10^4 t	Average per day per person, kg
1995	8.58	3.34	0.91	1.06
2000	9.44	3.76	1.03	1.09
2003	10.6	4.89	1.34	1.26

The problem of waste is the gap between treatment capability and waste output. The disposal of waste is simple landfill. Because the waste treatment is slow and insufficient, many nooks and corners become the temporary stacking places, especially in the transition belt between urban and rural. Some towns dump waste to rivers and lakes chronically. There is pollution in the whole processes of collecting, transiting and disposing, and the most final treatments do not meet the national criterion mostly. The inadequate treatment and accumulation of living solid waste put stress on the living environment and deface the natural landscape seriously.

2.2 Coupled curves between WUA development and environment

Recent empirical research has examined the relationship between certain environmental indicators of environmental degradation and economic income. It is concluded that in some cases an inverted U curve (environmental Kuznets curve), logarithmic curve or "S" curve exist between these variables (Ansuategi and Escapa, 2002; Huang and Fang, 2003; Liu *et al.*, 2005). The timing of changes in linkages between environment and the urban development is difficult to track over the past decades given data limitations in the whole WUA. So, based on GDP per capita, urbanization ratio and environmental data in Ezhou during 1991—2000, the cubic equation curves were established and the relationship between typical environmental indices and urban development was analyzed in this sector.

The coupled curves reveal the structural change of water pollution. There are two turning points when the GDP per capita is 5000 and 10000 RMB Yuan in Fig. 5a. After a quick fall, the curve entered a steady-going period from the first point, and then it began to decrease at the second point. The discharge of living sewage is increasing rapidly when the urbanization ratio is above 25% in Fig.5b. This change implies that when economic growth reaches a higher level, the industrial sewage discharge has a downward trend.

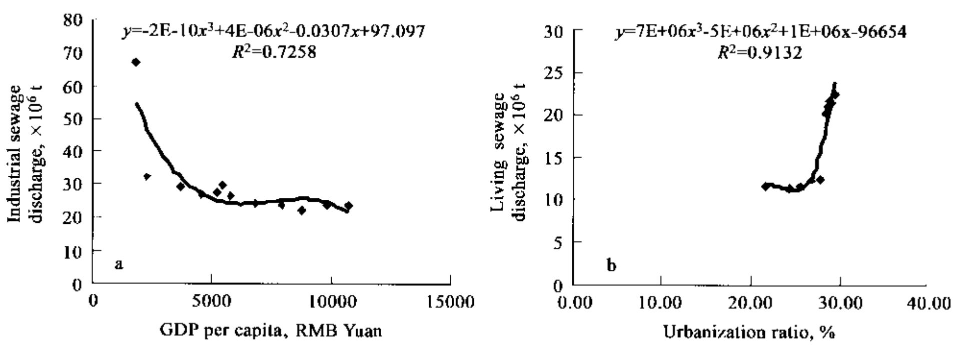

Fig.5 Coupled curves of industrial and living sewage with GDP per capita and urbanization ratio in Ezhou during 1991—2000

The statistical data has already confirmed the result that the living sewage discharge has gone beyond the industrial discharge and become the main water pollutant since 2000. This structural change profited from the improvement of the industrial technology and sewage treatment in productive process. But the living pollution sources are more extensive and difficult to control, so it is evident that living sewage grew in pace with the step of urbanization.

The coupled curve in Fig.6a has two turning points in 3000 and 8000 RMB Yuan. It reveals that the industrial solid waste rose quickly during the period of the economic upsize from 3000 to 8000 RMB Yuan. It began to decrease at the second turning point of 8000 RMB Yuan. Due to the data limit, it is difficult to infer whether this descending will continue or not. But according to the experience at home and abroad, the industrial solid waste will exert lower pressure on urban environment along with the improvement of resource utilization technology.

The coupled curve in Fig.6b shows that the waste gas discharge is ascending in fluctuation with the increase of GDP per capita. The fluctuation of the

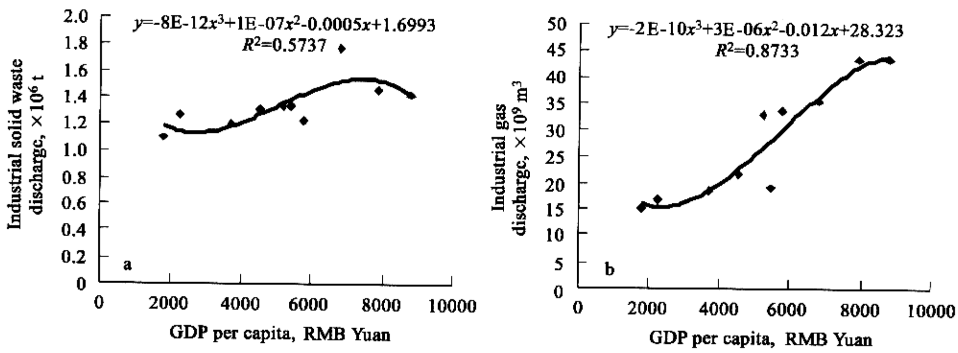

Fig.6 Coupled curves of industrial solid waste and gas discharge with GDP per capita in Ezhou during 1991—2000

curve can be explained by the heavy industrial structure. In 2002, the second industry is 51% of GDP and there are many cement plants, iron and steel plants in Ezhou City. The output of industrial waste gas will remain incremental trend as long as the heavy industrial sectors hold a leading post in near future, and the measures to adjust industrial structure and control pollution sources are not fully implemented. The analysis indicates that industry growth will exerted a durative pressure on the coupled urban-environment system and exacerbate the already polluted environment in WUA.

2.3 Ecological impacts of urban encroachment

Both residential space and industrial production require extensive land. Woodland, grassland, farmland, wetland and lakes were encroached by urban sprawl and economic activity in WUA. Especially, the wetlands and lakes have endured rapid encroachments by both residential and agricultural land uses, and are under continuing threat due to population growth in the region. All kinds of hydraulic works have also cut off the connections between lakes and rivers and the chain reaction of the silt and the reduction of incoming water have resulted in the lakes and wetlands more fragmented and eutrophicated. Consequently, the ecological functions of lakes and wetlands decreased significantly.

As agriculture becomes less important to the regional economy, the direct losses of the natural wetlands are linked to expansion of the city (Walker, 2001). The enormous economic gain behind real estate exploitations pull the wool over people's eyes and the impacts of these activities on the ecological degradation of lakes and wetlands are apparently ignored in WUA. From the landsat TM images of 1991 and 2002 (Fig.7), we can see that the area and shape of Donghu, Shahu, Nanhu and Yanxihu near Wuhan have changed largely due to the building encroachments. Carrying capacity diminutions for floods, biomass reductions, rare species habitats lose as well as biodiversity decrease are evident. Donghu, for example, has been almost completely besieged by buildings and its area has decreased 729698 m^2. Zooplankton, zoobenthos and fish declined evidently, and some fishes such as sturgeon, mandarin fish and whitebait become endangered species.

In addition, soil erosion is serious because of unreasonable exploitation of land resources, such as mine exploiting, road building, and new open economic zones. Soil erosion is often neglected in plain and the level of recovery is quite low (<25%). Many development projects did not take any measures to prevent soil erosion. For instance, mine exploiting in Wuhan, Ezhou, Xiaogan, Huangshi, Huanggang and Xianning has brought serious damages of desertification, landslip and landscape ruin.

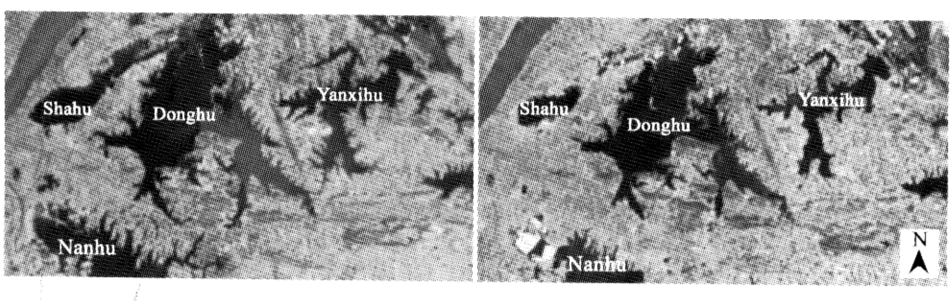

Fig.7 The area and shape changes of lakes(left: 1991-07-19; right: 2002-07-09)

3 Conclusions and strategies

Based on the analysis of the main environmental pollutants changing and the coupled curves, this paper states there are strong links between the urban environmental quality and industry growth and urban sprawl. After the period of 1980s—1990s when the growth of pollutants discharge rose rapidly to a peak and the environmental quality was drastically deteriorated, the increase of industrial pollution began to slow down from 2000s. The ingredients of environmental pollution are changing because the untreated living pollution and agricultural non-point pollution which had been paid no attention before became the non-negligible sources for environmental problems. The raise of NOx in air pollution is owing to the increasing automotive vehicle tail-gas in cities. The environmental pollution may be briefly summarized as follows: point and non-point pollutions coexisting, living pollution and industrial discharge overlying, new and second-hand pollution interacting. Urban sprawl and economic activity also have obvious impacts on ecological system in WUA.

The procedure of urbanization and industrialization is to continue, but how to reduce its profound environmental impact? The urban sustainable development has become a common sense. However, the course of achieving sustainable development is uncharted. The merging of economic and environmental policies in urban development is very necessary and significant at the large urban agglomeration region. Four proactive and long-term strategies need to be adopted to provide prior guidance and better protection of the development in WUA; furthermore, these strategies must be interwoven to support a sustainable future of WUA.

3.1 Turning to ecologically sound industrial development

Urban sustainable development requires not only passive "protecting" the environment, but also the change of active economic and social activities to reduce the urban pollution (Huang *et al.*, 1998). The key lesson learned from other urban agglomerations is that the development of an area should be based upon the harmoniousness between economy and ecosystem. The development has to be in a new framework which is ecological prior and environmental oriented. The government should support the ecologically sound enterprises and supervise the environmental impact of production activity across their entire life cycles. Accordingly, the enterprises need to reconsider their current management and production models to adapt themselves to the environmental demands both of legal and of social. Especially when the private businesses become more active, the environmental management of private enterprises should be taken extra care.

3.2 Planning for ecological and environmental cross-boundary construction

A coordinating mechanism of crossing boundaries should be established for WUA in order to handle the environmental issues effectively. Integrated environmental protection strategy should be adopted to provide guidance to the whole region. Especially, when relating to trans-boundary pollutions, the prevention and harness should be reinforced in every city of WUA equally to avoid the pollution transfer. Take the case of the surface water pollution. In terms of the pollution patterns and origins, except for the protection of the trunk rivers, the reparation of medium and small rivers should be enhanced and united regional agency of water environmental management should be established. The restoration effort should be underway to recover the lost hydrologic function of lakes and wetlands by reconnecting the lakes and rivers to natural conditions in WUA.

3.3 Increasing the environment—related investment

In WUA, the bottleneck of environmental protection is that the environmental infrastructure lags behind the pollution increase. Environment-related investment amounted to lower than 1.5% of the total GDP by 2003 in WUA. For this reason, the government should promote the investment to build more pollutant treatment plants and improve the running level of environmental infrastructure in order to increase the sewage treatment ratio and mitigate the environmental pollution under the market economy. Environmental protection needs the joint efforts of the governments, enterprises and the public.

3.4 Different guidance to different types of cities

These 9 cities are imbalance and conflict with each other in the levels urbanization and the industrial stages: Wuhan towers above the others; Huangshi, Ezhou, Qianjiang and Xiantao are active and potential; Xianning, Xiaogan, Tianmen and Huanggang are sluggish. Based on the premise of integration, cities should also have the different environmental management guidance. Under the essential prerequisite of protecting environment, it is acceptable to remain proper development space for the periphery eight cites in a certain period depending on their current environmental and socio-economic conditions. Comparatively, it is also acceptable to set high criterions on Wuhan city. Wuhan should carry into the effect the new framework of ecological preference and environmental guide, and make strict demands on environmental admittance. The small towns should increase their control of industrial and agricultural pollution, especially that of the small industrial enterprises (producing iron and steel, coal, chemical fertilizer, cement and machinery) and the harness of livestock and poultry dejecta should be enhanced to make them resourceful, reducible and innocuous.

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