International Journal of Sustainable Development & World Ecology 12 (2005) 291–299

Environmental quality and its impact on the local economy: A case study from Dongguan, South China

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Key words: Environmental pollution, economic growth, division of area, Dongguan City

SUMMARY

Industries that pollute the environment developed in the early 1990s in Dongguan City, especially those in the middle and lower valley of the Dongjiang River (waterside area) have seriously affected water and air quality and hence have affected soil quality through polluted water irrigation and precipitation. Investigation of the economic growth and environmental pollution in the 32 township units in the City from 1990 to 2000 also reveals that environmental pollution has affected the history of the development of the towns or townships in the waterside region in the delta of the River Dongjiang, especially the towns near the river mouth, and has prevented their industry from upgrading and hence has slowed down their economic growth. The impact of environmental pollution on economic growth is most severe in the towns along the lower valley, or in down-wind regions. In contrast, economic development in the protected area of the upper valley of the waterside region indicates that environmental protection that strictly controls the discharge of pollutants does not restrict the development of the local economy.

INTRODUCTION

Located in the southern part of China, between 113°30′–114°10′ and 22°50′–23°10′, east of the Pearl River Delta Economic Zone (the PRDE zone), Dongguan is characterized by a river distributed plain in its northern part and by low mountains and hills in the south of the City. The river distributed area, the location of the townships in the Dongjiang River Delta, can be divided into two parts: the water source area situated in the upper valley of the river, and the waterside area in the middle and lower part of the river. The former includes the four townships of Shipai, Hengli, Qishi and Qiaotou, making up 8.61% of the city, with an area of 213 km^2. This area has been strictly protected from environment pollution because it is the most important drinking water source for Hong Kong, and Shenzhen City. The latter includes 11 townships or districts, making up 22.21% of the city, an area 549.7 km^2, where the plentiful water resources were once generally considered to indicate a huge environmental

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capacity. As a result, many polluting industries were given the opportunity to establish themselves there. The southern mountain area, with an area of 1018.6 km^2, includes nine townships and makes up 41.16% of the area of the city. The middle transitional area includes eight townships or districts, with an area of 693.5 km^2, making up 28.02% of the city (Figure 1). Thus, Dongguan City consists of four distinct divisions or areas (Figures 2 and 3, Table 1).

In situ sampling and monitoring of soil quality (vegetable-growing soil and farmland) of four divisions of the area indicate a synchronization tendency between soil, water and air quality. Statistical data from 1990–2000 have revealed a serious impact of environmental pollution on the local economy.

METHODS

Mean values of soil monitoring results were calculated using SPSS software and then compared with statistical data on air and water quality. The relationship between environmental quality and

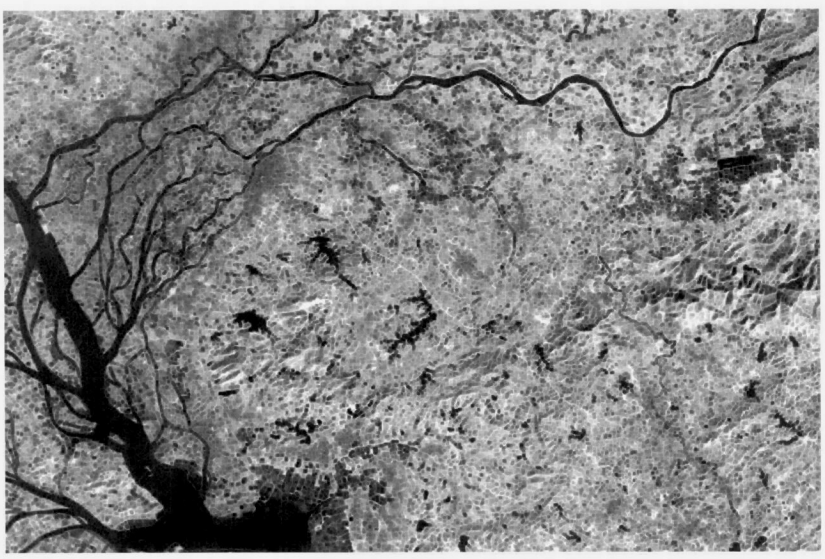

Figure 1 Landsat ETM Image of Dongguan City

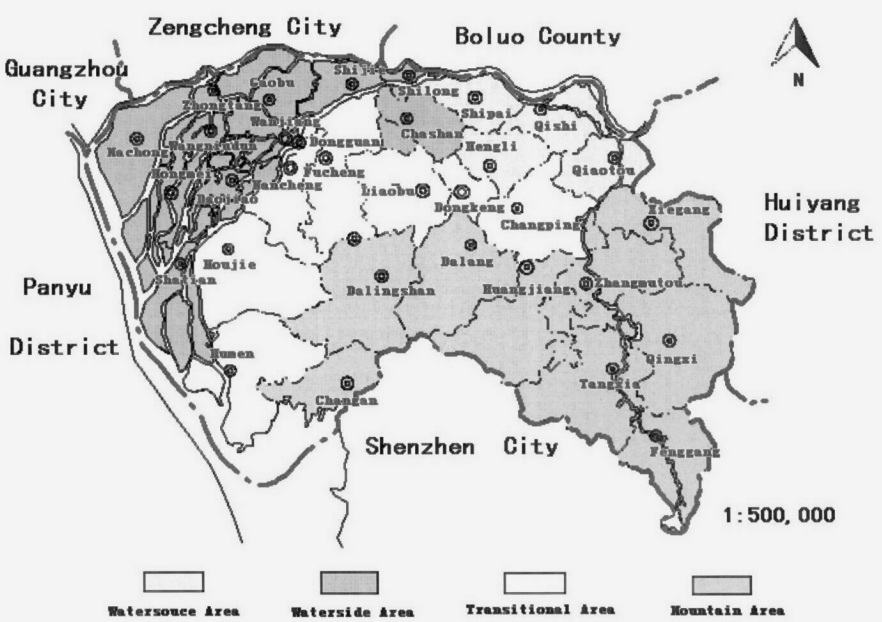

Figure 2 Divisions of Dongguan City

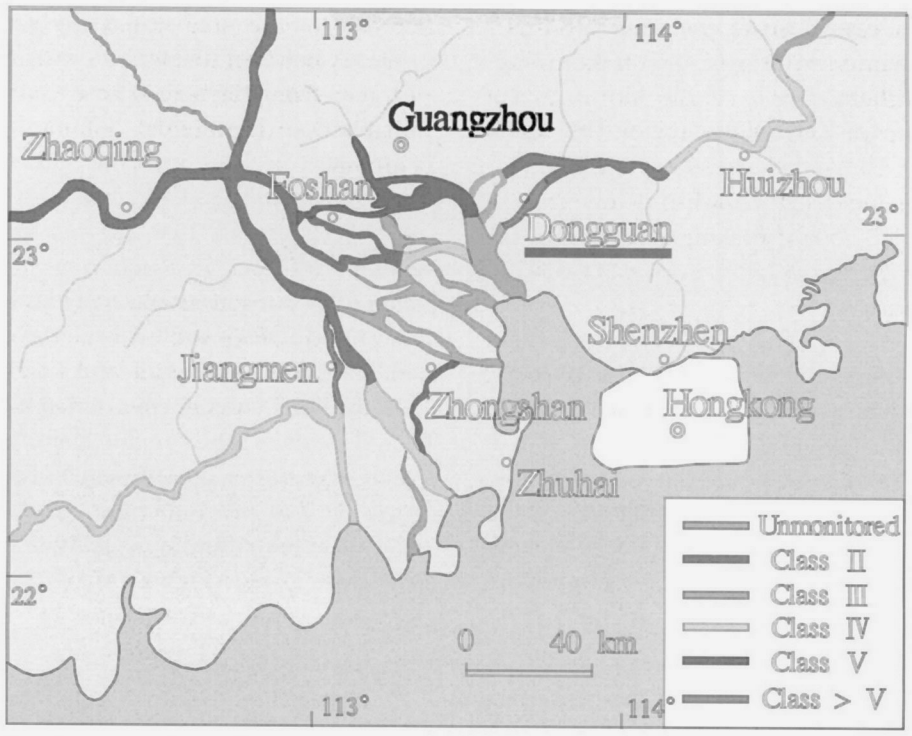

Figure 3 Grades of water quality in the Pearl River Delta

Table 1 Four divisions of Dongguan City

		Registered permanent residents		
Region	*Area km²*	*1994*	*2000*	*Township or district*
Waterside area	549.7	479 142	524 550	Machong Township, Wangniudun Township, Shatian Township, Hongmei Township, Daojiao Township, Wanjiang District, Zhongtang Township, Gaobu Township, Shijie Township, Shilong Township, Chashan Township
Mountain area	1018.6	256 984	272 178	Changan Township, Dalingshan Township, Dalang Township, Huangjiang Township, Zhangmutou Township, Qingxi Township, Xiegang Township, Tangxia Township, Fenggang Township
Water source area	213.0	129 927	137 627	Shipai Township, Hengli Township, Qishi Township, Qiaotou Township
Transitional area	693.5	431 965	481 040	Changping Township, Dongkeng Township, Liaobu Township, Fucheng District (Dongcheng District), Guancheng District, Huangcun District, Houjie Township, Humen Township

economy were all based on the statistical data. Investigations were also made in order to identify the relationship between the distribution of polluting industries and environment pollution.

As a result, a pollutant load (W) was proposed and calculated, in which COD and SO_2 represented the pollutants of water and air, respectively.

$$W = 1/2\ (A/\Sigma A + B/\Sigma B) \times 100\%$$

Where W = pollutant load of one region (%); A = discharged amount of SO_2 of one region (kg); ΣA = total discharged SO_2 of the city; B = discharged amount of COD of one region (kg); ΣB = total amount COD of the city.

RESULTS

Interaction of water, air and soil

Industrialization and urbanization have seriously affected the water quality of Dongguan City, where the water quality was found to be even worse than in other cities (Zhu *et al.* 2002). At the same time, the heavy polluting industries along the Dongjiang River, especially brick-making or cement-making industries, have degraded the air quality of the waterside area. Subsequently, the polluted water and air have contaminated the soil (vegetable-growing soil and farmland) through irrigation with polluted water (widely practiced in China) and precipitation. Hence, the pollutants have moved from water and air into the soil, especially the vegetable-growing soil and farmland (Table 2).

Table 2 reveals that the waterside area has received most of the pollutant load (73.42%), followed by the transitional area (14.66%). The SO_2 and COD discharges of the former made up 60.94% and 85.91%, respectively, of the total for the city.

At the same time, we can see that the mean values of pollutants of soil samples from the four areas, which were under the influence of polluted water irrigation and precipitation, had the same tendency as the water and air quality of the same area (Figures 4, 5). Heavy metals in soil samples from the waterside area and the transitional area were much

Table 2 Comparison of pollutant discharge of four divisions of Dongguan City

		Pollutant discharge in 2000				
		SO_2		*COD*		*% of regional pollutant load to % in the city*
Region	*% area*	*kg*	*%*	*kg*	*%*	
Total for 32 towns or townships	100	33 594 387	100	17 777 984	100	100.00
Waterside area (11 townships or districts)	22.21	20 473 405	60.94	15 272 234	85.91	73.42
Mountain area (9 townships)	41.16	5 171 732	15.39	991 053	5.57	10.48
Water source area (4 townships)	8.61	777 654	2.31	97 311	0.55	1.43
Transitional area (8 townships or districts)	28.02	7 171 596	21.35	1 417 386	7.97	14.66

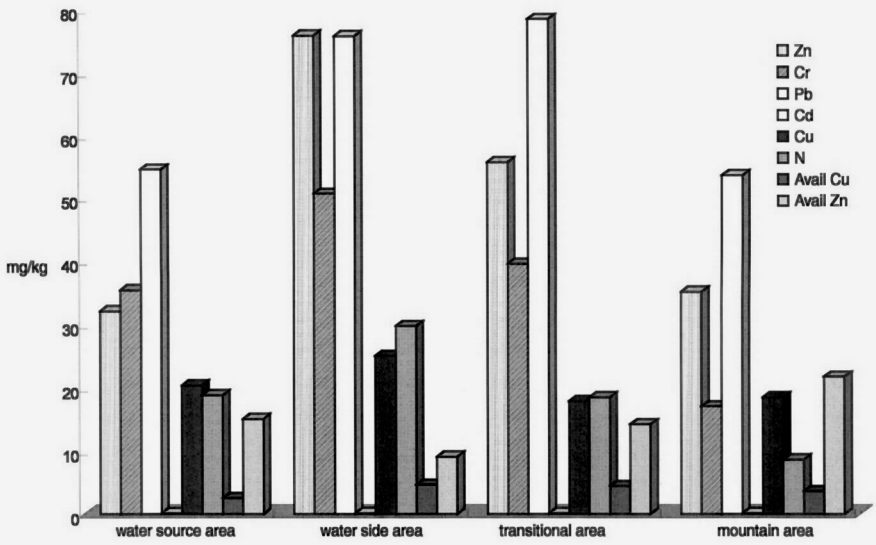

Figure 4 Data of vegetable garden soil pollution of four divisions of Dongguan City

higher than those from the river mouth area and mountain areas.

Impact of environmental pollution on the local economy

Located between the two central cities, Shenzhen and Guangzhou, Dongguan City was in the best position to take advantage of the facilities of both cities. In the early 1990s, large numbers of industries moved into Dongguan City as a result of the implementation of industrial upgrading programmes in Shenzhen and Guangzhou. Dongguan was at the height of its economic development at that time, especially in the waterside area, where the plentiful water attracted many resource-consuming industries which played an important role in the economic development of the waterside area in the early 1990s.

After 1995, Dongguan moved into the fast lane of economic development and the average annual increase of the economy of all 32 towns or townships of the city between 1995 and 2000 was 20.18%. However, different development tendencies appeared in the four divisions of Dongguan, and especially in the north (waterside area) and south (mountain area).

Investigations of the industrial distribution of Dongguan City indicate that most of environmental polluting industries were concentrated in the waterside area, which was consistent with the pollutant load distribution and the SO_2 and COD distributions (Table 2) and confirming the validity, to a large extent, of the statistical data.

In comparison with the sharp decline in the GDP ratio of the waterside area (11 townships or districts) in Dongguan City between 1990 and 2000 (falling from 31.03% to 23.32%), the GDP of the nine townships of the mountain area increased from 19.29% to 26.98% in the same period (Figure 6).

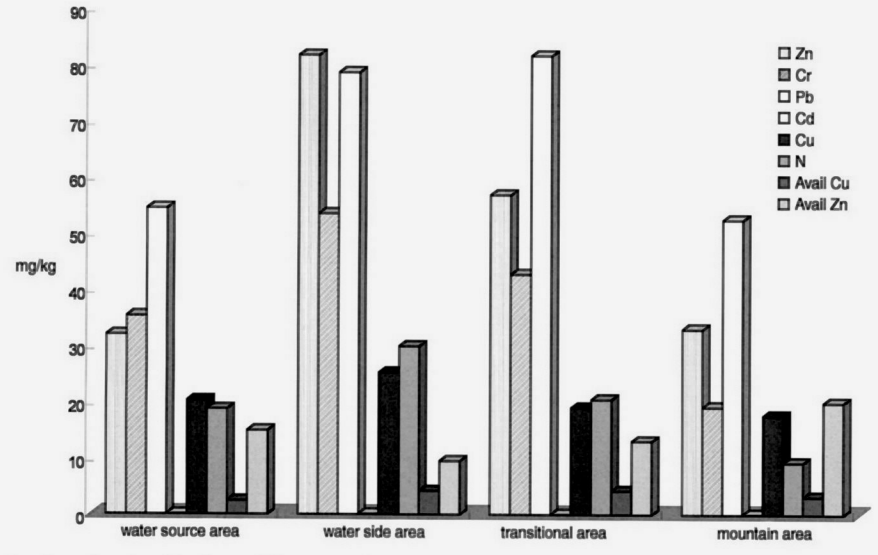

Figure 5 Data for farmland pollution of four divisions of Dongguan City

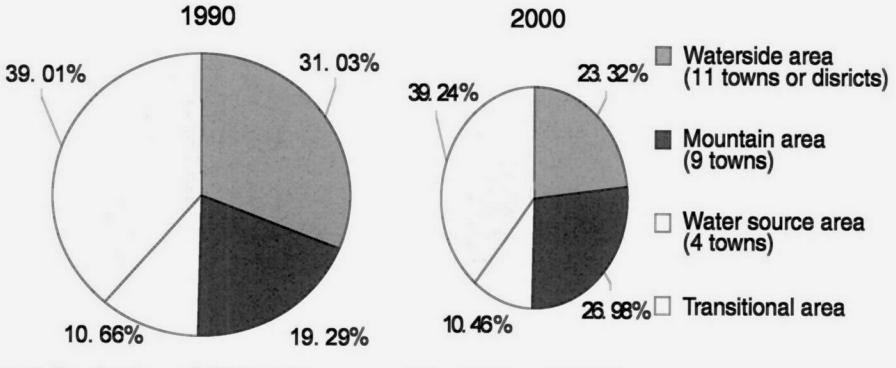

Figure 6 Regional distribution of GDP on Dongguan City (1990 and 2000)

What was the main reason for these drastic changes? Located in the northern part of Dongguan City, the waterside area (11 townships or districts) was once famous for its good water and soil conditions. In 1994, there were 479,100 registered permanent residents, accounting for 34.17% of the total population of the city, and it was the most populous area of Dongguan City. Sufficient water resources and convenient traffic both on land and water attracted many resource-consuming, heavy polluting industries, such as brick-making and cement-making industries. With the development of these heavy polluting industries more and more pollutants were discharged into the local environment, exceeding the local environmental capacity, impairing the ecological environment and making it difficult to introduce new industries and foreign investment.

It was noticeable that the four townships of the water source area, where the development of polluting industries was strictly restricted by a water source protection policy, maintained the same speed of economic development as the average speed of the city. The ratio of the GDP of this area accounted for 10.5% of the GDP of the city during the 1990s. These four townships, though starting from different levels, maintained nearly the same speed as that of the city (20.18%), about 19.5% between 1995 and 2000. Moreover, the increasing speed of the economic growth of Qiaotou township, which had the smallest pollutant load, was higher than the other three townships, indicating that strict control of pollutant discharges does not restrict the development of the local economy (Table 3).

The mountain area (involving nine townships, situated in the south part of Dongguan City and near Shenzhen City) was once the impoverished settlement of Dongguan. There were 257 000 registered permanent residents in 1994, accounting for only 20.2% of the city total, although the area is almost twice that of the waterside area. The population density was 252 persons per km^2, the lowest in the city. The scarcity of water and the high expense of traffic in this area in the early 1990s prevented the establishment of resource-consuming and heavy polluting industries. Thus, in the 1980s, when extensive industries were the mainstay of economic development of Dongguan, the mountain area lagged behind. In 1990, the total GDP of the nine townships or districts of the mountain area was only 870 million Yuan, accounting for 19.29% of the city. However, the untouched ecological environment of this area was reserved and became a precondition for developing hi-tech industries after the mid-1990s. In recent years, this area has become the main centre of economic development for Dongguan.

From Figure 7, we can see an intersection of the two lines that represent the economic levels of the waterside and mountain areas. To the left of the intersection (1995), the GDP of 11 townships or districts of the waterside area was higher than that of the nine townships of the mountain area. To the right of the intersection, the GDP of the mountain area began to exceed that of the waterside area, and the gap between these two areas has increased since then. In 2000, the GDP of the mountain area reached 11 252 million Yuan while that of the waterside area was only 9725 million Yuan. From 1995 to 2000, the average annual increase in the economy of the waterside area was 1.9% lower than that of the city (20.18%), and that of the mountain area was 1.9% higher than that of the city. The amount of pollutants of the two areas in 2000 can readily explain the different tendencies of the two areas. In 2000, discharged SO_2 and COD of the 11 townships or districts of the waterside area accounted for

Table 3 Comparison of economic development and pollutant discharge of four townships in the water source area

Township	*Area* km^2	*GDP/million Yuan*		*% average annual increase*	*Pollutant discharge in 2000 (kg)*		*% township pollutant load to % of city*
		1995	*2000*		SO_2	*COD*	
Hengli Township	50	421.38	1020.80	19.36	437 394	4 876	0.66
Shipai Township	56	337.69	823.89	19.53	292 740	63 373	0.61
Qishi Township	51	481.95	1155.03	19.10	46 610	15 716	0.11
Qiaotou Township	56	548.59	1361.40	19.94	910	13 346	0.04
Total for the 4 townships	213	1789.61	4361.12	19.50	777 654	97 311	1.43

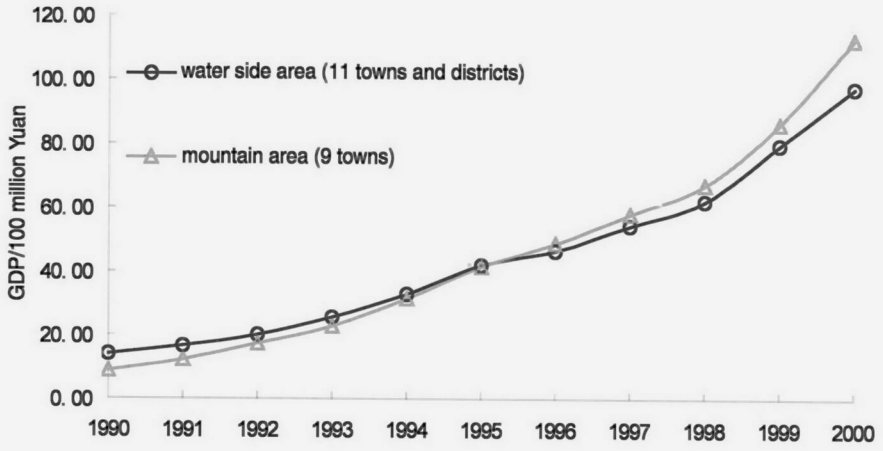

Figure 7 Comparison of economic development of waterside and mountain areas of Dongguan City (1990–2000)

60.94% and 85.91% of the city, respectively, and their pollutant loads accounted for 73.42% of that of the city. Meanwhile, the corresponding values for the nine townships of the mountain area were only 15.39%, 5.57% and 10.48%.

The impact of local environmental pollution on the lower valley or down-wind regions

The transitional area was situated between the waterside area and the mountain area (Figure 2) was characterized by its convenient highway and railway traffic and was the cultural and administrative centre of Dongguan City. In 1994, there were 432 000 registered permanent residents, accounting for 33.28% of the total. The population density of this area was 623 persons per km^2, much higher than that of the mountain area, although lower than that of the waterside area. From 1995 to1998, an increased potential for the economy was found in this area, and the GDP of its eight townships and districts rapidly increased from 6499 million Yuan to 11 235 million Yuan, and the GDP of the city also increased from 39.07% to 41.41%. The amount of SO_2 and COD discharged into this area represented only 21.35% and 7.97% of the total of the city, and its pollutant load was only 14.41% of that of the city (Table 2). The amount of pollutants resulting from the economic output of this area was even lower than that of the mountain area.

However, the environment pollution (especially air pollution) of the waterside area has obviously affected its economy. Since 1998, the increasing rate of economic growth of the transitional area has lagged behind that of the mountain area. The GDP of the transitional area dropped below that of the city to 41.41% in 1998 and to 39.24% in 2000, while the percentage for the mountain area increased from 24.73% to 26.98%, where the better natural environment remained.

Even the 11 townships or districts of the waterside area showed a close relationship between economic development and the township position in both the upper and lower valleys of the river, reflecting the effects of environmental quality. Between 1995 and 2000, the average annual increasing in the economy of these 11 townships or districts was 18.3%, although the rate of increase for different sections of the waterside area was quite different. The average annual increase for towns located in the upper valley, which experienced the lowest pollutant load, was 22.24%. The percentage for towns or districts of the lower valley that were subjected to much of the pollution (especially water pollution) from the middle valley, where the environment quality was worst in the city, was only 12.56%. At the same time, the average annual increase in the economy of the three townships or districts of the middle valley of Dongjiang River was 17.56%. There was a 5% difference between these three sections. Obviously, the lower valley area was most hit by environment pollution (Table 4).

The pollutant load of the 11 townships or districts of the waterside area accounts for 73.42% of the total for the city (Tables 2 and 4). These pollutants were mainly concentrated in the middle and lower valleys, the former accounting for 41.6% and the latter for 26.25% of the pollutant load of the city while, for the four townships in the upper

Table 4 Comparison of economic development and pollutant discharge for different sections of the waterside area

Regions	*Area km²*	*GDP/million Yuan* 1995	2000	*% annual increase*	*Pollutant discharge in 2000 (kg)* SO_2	COD	*% regional pollutant load to % of city*
Lower valley (4 townships)	243.2	1213.98	2193.94	12.56	6 281 180	6 010 115	26.25
Middle valley (3 townships or districts)	173.5	1268.78	2849.01	17.56	12 684 656	8 079 587	41.60
Upper valley (4 townships)	133.0	1715.18	4682.13	22.24	1 507 569	1 182 532	5.57
Total for 11 towns or townships	549.7	4197.94	9725.08	18.30	20 473 405	15 272 234	73.42

valley it was only 5.57%. It is clear that the three townships or districts in the middle valley had the greatest exposure to pollutants. However, it is the four townships in the lower valley that received much of these pollutants and had the slowest economic development in the three sections of the waterside area. It is obvious that the impact of environmental pollution from an area on economic growth is not restricted to that area, and the areas most affected are often the towns along the lower valley or in the down-wind regions.

RELIABILITY OF THE DATA

Statistical data on the social economy that were used in this paper were all from published material (Bureau of Statistics 1997, 1999, 2001), but the environmental data were provided by the Environment Protection Bureau of Dongguan City and are unpublished. General doubts on the reliability of statistical data make it necessary to discuss their validity. The social economy data include the areas, numbers of registered permanent residents and GDP. The area data for the 32 townships or districts were newly revised data, including both land and water areas. The absolute error of area of each township or district was less than 1 km^2. Prior to the 1970s, the numbers of registered permanent residents was the most reliable data in China. However, with the introduction of restrictive family planning policies, couples with more than one (in an urban area) child or two (in a rural area) may fail to register their additional children in order to escape a fine. This failure was prominent in most rural areas and has resulted in a smaller registered population than the actual population. Since the late 1980s, and especially after the mid-1990s, more and more farmers have looked for work in cities but were not included in the permanent registered population in the city. Some impoverished settlements were characterized by accelerating outward migration of agricultural labour, where the registered population was usually more than the actual population. In contrast, some advanced areas have attracted more and more immigration, so that the registered population was usually much less than the actual population. As one of the most developed cities of China, Dongguan is a city where the actual population was much larger than registered population. Registered populations in 1994 and 2000 used in the paper reflect the attraction of the natural conditions for the people, rather than the results of economic comparisons of different areas.

Private or overseas funded enterprises play an important role in the Dongguan economy; and it is impossible that they may have overated their GDP because more GDP means more tax. On the other hand, local government will do its best to increase government revenue. It is likely, therefore, that the error in GDP will be small, and the variability in statistical data for different areas will be eliminated by comparison of the rate of increase.

Data on discharged amounts of SO_2 and COD were provided by the Environmental Protection branches of townships or districts. These data were obtained by calculating the discharged level of unit production for each pollutant discharging enterprise. For enterprises, increased pollutant discharges signified increased production values, and resulted in increased taxes; to local governments, increased pollutant discharges reflected badly on their administrative performance. As a result, enterprises and governments tended to undervalue discharged amount of pollutants. However, the Environmental Protection branches of

townships or districts were directly managed by the Environmental Protection Bureau of Dongguan City and the production values of polluting industries were very clear, so the discharged amount of pollutants were unlikely to be overvalued. Thus, the data of the discharged amount of pollutants, though perhaps undervalued, were not far from reality.

CONCLUSIONS

Environmental pollution has seriously affected the economic growth and full realisation of the advantages of the towns or townships in the waterside region of the delta of the River Dongjiang (especially the towns near the river mouth), and has prevented industry from upgrading. Close relationships between water, air and soil have been revealed, and water and air pollution has affected the soil quality of Dongguan.

Although developing industries that pollute the environment may increase short-term prosperity, regional sustainable development will be seriously affected. The impact of the environmental pollution from an area on economic growth is not restricted to the immediate area, and most effects occur in the towns along the lower valley (water pollution) or in down-wind regions (air pollution).

The experience of the four townships in the water source area indicate that environmental protection through strict control on the discharge of pollutants will not restrict development of the local economy.

ACKNOWLEDGEMENTS

This study was funded by Guangdong Provincial Natural Science Fund Program (No.990529) and Guangdong Provincial Key Scientific Programs (2002C32203 and 2003C32604).

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