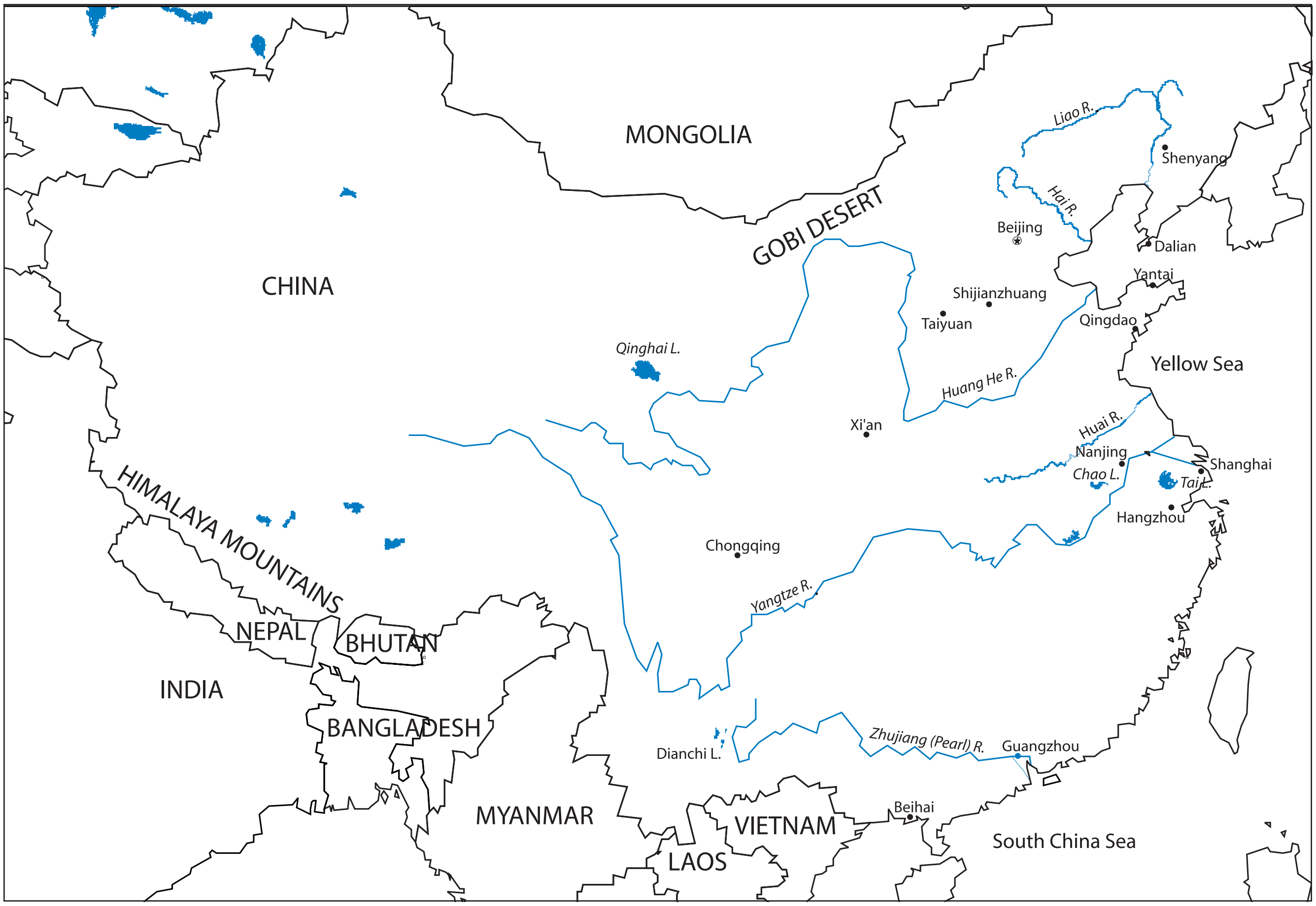
Regional Profile | China's Health and Environment



No country better typifies the confluence of trends discussed in this report—nor the challenges they pose to environmental quality and public health—than does modern China. Since the economic reforms of 1978, China has experienced dramatic industrialization and rising energy use against a backdrop of population growth and unprecedented urbanization. China's astounding industrial growth over the past two decades has created a country poised to become a major economic power in the 21st Century. Per capita, China is still one of the world's poorest countries, yet the future looks promising—incomes are rising, poverty rates are falling, and life expectancy is up. Yet, along with these gains, China is grappling with some of the most serious environmental problems on the planet, which in turn could prevent China from sustaining high levels of economic growth in the coming decades.

Recognizing the urgency of these problems, the Chinese Government has endorsed a suite of policies to curb air and water pollution. The extent to which these policies are successful has direct bearing on not only the health of the Chinese people and the local environment but the global environment as well.

Encompassing a geographically vast area with a number of distinct ecological zones, China extends from the massive and sparsely populated Gobi Desert and the mountains of the southwestern Himalayas to the densely inhabited valleys of the eastern coast. As the world's most populous country, with more than 1.2 billion people, China's economic growth is the fastest and most sustained of any major country in the world, rising an average of 10 percent annually over more than a decade (1). In fact, some autonomous regions in the golden southeastern coastal zones have grown nearly 20 percent annually, doubling in less than 4 years (2).

Industry is China's largest productive sector, accounting for 48 percent of its gross domestic product (GDP) and employing 15 percent of the country's total labor force (3). In the 1990s, the output of China's 10 million industrial enterprises has increased by 18 percent annually (4). Without a doubt, Chinese industry is largely responsible for lifting many millions of people out of poverty. It also underlies a huge and growing demand for energy.

China's demand for high-grade energy such as oil and natural gas will increase rapidly, although coal will continue to dominate the energy structure, accounting for more than 75 percent of total energy production. From 1990 to 1995, China's oil demand grew at 4.3 percent annually, while oil production increased only 1.2 percent each year. As a result of these trends, China has become a net oil importer (5).

Along with industrialization has come rapid urbanization, especially in what is known as the southern coastal crescent that runs from Guangzhou to Shanghai. The proportion of the population living in cities has grown about 50 percent since 1980. Some 370 million people now live in cities, and this number is expected to grow to 440 million by the turn of the century (6). A World Bank model predicts that by the year 2020, 42 percent of China's population, more than 600 million people, will live in urban areas overwhelmingly concentrated in the eastern and southern coastal provinces (7).

Since the political transformation of 1949, dramatic and extensive social improvements have accompanied China's growth. In 1949, the new People's Republic of China faced a massive burden of nutritional deficiency and infectious and parasitic diseases. More than half the population died as a result of infectious and other nondegenerative diseases before reaching middle age—a pattern still common throughout much of the developing world. Since 1949, the average life span in China has risen from 35 years to the current 70. The infant mortality rate has dropped from 200 per 1,000 to 31 per 1,000. Infectious diseases, while still a serious problem in some parts of the country, claim the lives of a mere 0.0004 percent of the population each year (8). The decrease in morbidity and mortality rates associated with infectious diseases in China is a remarkable achievement for the world's most populous country. This decline can be attributed to an aggressive campaign to improve primary health care and tackle infectious diseases (9).

However, over the coming decades, China's deteriorating environment threatens to undermine the gains that rising incomes would otherwise bring. China's rapid industrialization, urbanization, and economic growth are contributing to respiratory diseases and chronic illnesses such as cancer. Levels of particulate air pollution from energy and industrial production in several of China's megacities, such as Shanghai and Shenyang, are among the highest in the world, leading to corresponding problems of lung disease in their populations. Water pollution in some regions, such as in the Huai River Valley, is also without parallel.

In 1996, the government annual report, *State of the Environment*, noted that environmental pollution was expanding into the countryside, and that ecological destruction was intensifying (10). Environmental problems are seriously affecting overall social and economic development in the country. *China Environment News*, a national newspaper of the National Environmental Protection Agency (NEPA), reported that in recent years, economic costs associated with ecological destruction and environmental pollution have reached as high as 14 percent of the country's gross national product (GNP) (11). More recently, the World Bank estimated that air and water pollution cost China nearly 8 percent of its GNP, around US$54 billion (12). Although solid scientific data are lacking, the government has identified environmental factors as one of the four leading factors influencing the morbidity and mortality of China's people today (13). The importance of environmental factors is well understood by some, as shown by a 1994 opinion survey about risks. Respondents who hold science or engineering degrees ranked risk from pollution ahead of natural disasters (14).

Responding to growing public concerns about the environment, the Chinese Government has officially named the environment as one of its top priorities and has committed itself to reversing the trend of environmental deterioration (15). Over the past decade, China has increased environmental spending, adopted market incentives, strengthened lawmaking and enforcement, and promoted nationwide environmental education. Decisions made in the next decade or two about energy, transportation, and agricultural technologies will largely determine how successful China will be in achieving its goal of sustainable development.

This case study describes the initial findings of an ongoing project between the World Resources Institute (WRI) and the Chinese Government to evaluate the links between environment and health in China. The goal of this collaborative project is to develop information and indicators that will enable decisionmakers to make informed choices about the environment, energy, infrastructure, and related issues.

The first section of this profile focuses on air pollution trends and the impact of air pollution on human health. Routine monitoring of air pollution and good hospital and health records have enabled researchers to gain a fairly clear picture of air pollution's impact on human health and what the future will hold if air pollution continues to worsen. Water pollution also presents a major threat to public health, although data in this area are less complete. Although data limitations prevent a comprehensive review, the second section reviews the most recent evidence concerning the extent of health problems associated with water pollution. The third section reviews China's laws and policies to protect the environment and health.

Air Pollution and Health Effects

POOR AMBIENT AIR QUALITY PREVAILS

"The residents of many of China's largest cities are living under long-term, harmful air quality conditions," Zhao Weijun, deputy director of the air pollution department of NEPA, reported in 1997 in *China Environment News* (16). China has long recognized air pollution as a critical problem. Ambient concentrations of total suspended particulates (TSP) and sulfur dioxide (SO_2) are among the world's highest. (See Figure China.1.) In 1995, more than one half of the 88 cities monitored for SO_2 were above the World Health Organization (WHO) guideline. All but two of the 87 cities monitored for TSP far exceeded WHO's guideline. Some cities such as Taiyuan and Lanzhou had SO_2 levels almost 10 times the WHO guideline (17).

Largely because of controls at power plants and within households, particulate emissions have not risen as much as might have been expected with the doubling of coal consumption. Overall, particulate emissions in China have remained relatively level since the early 1980s (18). In fact, in some large cities, ambient particulate concentrations have decreased markedly since the 1980s (19). In contrast, SO_2 emissions have roughly paralleled the increase in coal consumption, reflecting heavy coal burning and inadequate sulfur control measures.

Coal burning, the primary source of China's high SO_2 emissions, accounts for more than three quarters of the country's commercial energy needs, compared with 17 percent in Japan and a world average of 27 percent (20). China's consumption of raw coal increased annually by 2 percent between 1989 and 1993 (21). (See Figure China.2.) Meanwhile, SO_2 emissions increased by more than 20 percent and TSP increased by approximately 10 percent (22). The country is expected to burn 1.5 billion metric tons of coal annually by the year 2000, up from 0.99 billion metric tons in 1990 (23). Without even more dramatic measures to control emissions than are currently in place, the deterioration of air quality seems inevitable.

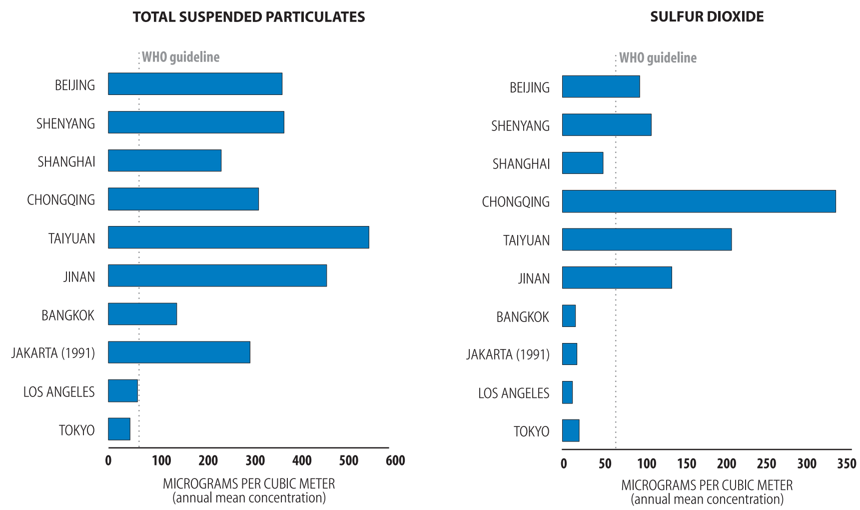
Particulates and SO_2 are the ambient air pollutants of greatest concern; both are byproducts of coal combustion. While industrial emissions of heavy metals and toxics are also significant contributors to air pollution in China, they are not routinely monitored and will not be addressed in this section.

The extent and type of air pollution in China vary dramatically by geographic region. SO_2 and particulate emissions are highest in the northern half of China, where coal is used to heat homes and other buildings for several months of the year and where industrial centers also depend heavily on coal burning. Yet, air pollution in the North would be much worse if not for the higher quality, cleaner coal that is available there. By contrast, the coal mined in the South is high in sulfur and extremely polluting, contributing to serious problems with acid precipitation, especially in the southwest provinces of Sichuan, Guizhou, Guangxi, and Hunan (24) (25).

Industry accounts for two thirds of China's coal use—industrial boilers alone consume 30 percent of China's coal. These boilers are usually highly inefficient and emit through low smoke stacks, contributing to much of China's ground-level air pollution, especially small particulates

China's Air Pollution Levels Are Among the World's Highest

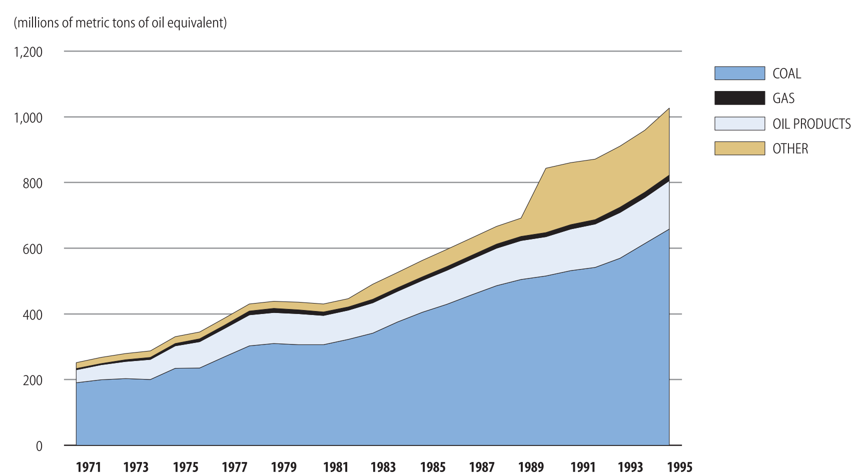
FIGURE CHINA.1 Ambient Concentrations of Air Pollutants, 1995



Source: The World Bank, *Clear Water, Blue Skies: China's Environment in the New Century* (The World Bank, Washington, D.C., 1997), Figure 1.1, p. 6.

China's Growing Consumption of Coal

FIGURE CHINA.2 Energy Demand in China, 1971–95



Source: International Energy Agency, *Energy Statistics and Balances: Non-OECD Countries, 1971–1995*, on diskette (Organisation for Economic Co-Operation and Development, Paris, 1997).

Outdated Vehicles Degrade Urban Air Quality

TABLE CHINA.1 Percentage of Emissions in Selected Chinese Cities Attributable to Motor Vehicles

	PERCENTAGE ATTRIBUTABLE TO MOTOR VEHICLES			
	CARBON MONOXIDE	HYDROCARBONS	NITROUS OXIDES	CATEGORIES
Beijing	48–64	60–74	10–22	District
Shanghai	69	37		District
Shenyang	27–38		45–53	District
Jinan	28		4–6	District
Hangzhou	24–70			Road
Urumqi	12–50			Road
Guangzhou	70		43	

Source: He *et al.*, "Status and Development of Vehicular Pollution in China," *Environmental Science,* Vol. 7, No. 4 (August 1996).

and SO_2. Inefficient and dirty boilers are particularly problematic because many of the industries that use them are located in densely populated metropolitan areas, placing populations in these areas at high risk of exposure. The residential sector accounts for approximately 15 percent of total coal use, yet is estimated to contribute to more than 30 percent of urban ground-level air pollution (26)(27).

Although the energy and industrial sectors are now the biggest contributors to urban air pollution in China, the transportation sector is becoming increasingly important. The number of motor vehicles on China's roads has tripled since 1984, climbing from less than 2.4 million in 1984 to 9.4 million in 1994 (28). By 2020, the urban vehicle population is expected to be 13 to 22 times greater than it is today (29). This trend will likely have a major influence on the future of China's air quality. The shift toward vehicle use is most apparent in China's big cities. For example, from 1986 to 1996, the number of vehicles in Beijing increased fourfold, from 260,000 to 1.1 million. Although this is only one tenth of the number of vehicles in Tokyo or Los Angeles, the pollution generated by Beijing motor vehicles equals that in each of the two other cities (30).

The problem stems not just from the growing size of the vehicle fleet but also from low emissions standards, poor road infrastructure, and outdated technology, which combine to make Chinese vehicles among the most polluting in the world (31). Vehicle emissions standards in China are equivalent to the standards of the developed world during the 1970s, and some domestic companies are manufacturing vehicles modeled after vehicles from 20 years ago. Actual emissions often exceed these standards: Chinese vehicles emit 2.5 to 7.5 times more hydrocarbons, 2 to 7 times more nitrous oxides (N_2O), and 6 to 12 times more carbon monoxide (CO) than foreign vehicles (32). In Beijing, Shanghai, Hangzhou, and Guangzhou, up to 70 percent of CO emissions have been attributed to motor vehicles. Cars also contribute a large share of hydrocarbons and N_2O in the cities where data are available (33). (See Table China.1.) As a result, although China's vehicle fleet is small compared with the developed countries, its large cities are already blanketed with smog.

A recent study in Beijing revealed that at all monitoring points within the Third Ring Road—a rough boundary separating downtown Beijing and its outskirts—the CO levels exceeded the national standard (4 micrograms per cubic meter per day). During the summer, ozone concentrations repeatedly exceeded the national standard, which is set on an hourly basis—often several times per day. In addition, concentrations of N_2O have almost doubled over the past decade (34).

Compounding these pollution problems is the fact that the burgeoning Chinese motor vehicle fleet is largely fueled by leaded gasoline. Although lead exposure is known to be a significant health hazard in China, no routine monitoring of environmental concentrations or blood-lead levels is performed. A few studies have been conducted and are described below. These scanty data suggest that ambient lead levels in the urban area of major cities such as Beijing are usually 1 to 1.5 micrograms per cubic meter—the national standard is 1 microgram per cubic meter. In some areas, ambient lead levels can reach as high as 14 to 25 micrograms per cubic meter (35). The health effects, described below, are significant, although recent and dramatic government actions to phase out leaded gasoline will likely have a major impact on this problem. Beijing and Shanghai as well as other cities have already begun to act, and the countrywide phaseout is expected to be complete by the year 2000.

HEALTH EFFECTS FROM AMBIENT AND INDOOR AIR POLLUTION

Air pollution is thought to be one of the leading risk factors for respiratory diseases, such as chronic obstructive pulmonary disease (COPD), lung cancer, pulmonary heart disease, and bronchitis, diseases that are the leading causes of death in China. The fact that men and woman have similar rates of these diseases, despite women's much lower smoking rates, provides evidence that this high disease burden is related to pollution (36).

Although only a limited number of epidemiologic studies have been conducted, air pollution has clearly contributed to both excess mortality and morbidity in China. At this stage, however, it is extremely difficult to tease apart which sources of air pollution have the greatest impact on human health, indoor or outdoor. In urban areas, there is a great deal of exchange between outdoor and indoor air, both of which are polluted from different sources—indoor primarily from the burning of coal for cooking and heating. Summaries of selected recent estimates of health impacts are presented to provide a more complete understanding of the complex relationship between air pollution and human health.

Based on dose-response functions from studies conducted within China and in other countries, the World Bank has estimated the number of deaths and diseases associated with air pollution among urban populations. Using the Chinese standards as a benchmark, they estimate the number of deaths that could be prevented if air pollution were reduced to those levels. According to their calculations, approximately 178,000 deaths, or 7 percent of all deaths in urban areas, could be prevented each year. Another measure of air pollution's impact on health is the number of hospital admissions from respiratory diseases. This study found 346,000 hospitalizations associated with the excess levels of air pollution in urban areas. Table China.2 summarizes the estimated health impact of both ambient and indoor air pollution in China (37).

In China, the effects of outdoor air pollution are compounded by those of indoor air pollution. Households using coal for domestic cooking and heating are especially at risk because coal emits very high levels of indoor particulate matter less than 2.5 microns in size—the size believed to be most hazardous to health. (These concentrations can be more than 100 times the proposed U.S. ambient air 24-hour standard.) Exposure to these small-sized particles is especially harmful because they persist in the environment and reach deep into the lungs (38).

Indoor air pollution affects both urban and rural populations. Nor is it simply a problem indoors: numerous studies have shown that intense indoor coal burning can affect ambient air quality as well. For instance, rural neighborhoods are generally unaffected by urban sources of air pollutants but can be extremely polluted from the burning of coal indoors. Table China.3 shows the extremely high levels of particulates in both rural and urban indoor environments (39). Indoor air pollution causes as many health problems as smoking, with the effects concentrated among women and children (40).

Although the proportion of China's households that burn polluting biomass fuels indoors for cooking and heating remains significant, it has been declining with the proliferation of alternative energy sources. Largely as a result of government investments, about one third of urban Chinese now have access to gas for cooking, and coal-burning households are increasingly turning to the use of cleaner, more efficient briquettes (41).

Perhaps the most compelling example of the health impact from indoor air pollution is the extremely high lung cancer rates among nonsmoking women in rural Xuan Wei County. Studies conducted by the United States Environmental Protection Agency (U.S. EPA) report that in the three communes with the highest mortality rates, the age-adjusted lung cancer mortality rate between 1973 and 1979 was 125.6 per 100,000 women, compared with average rates of 3.2 and 6.3 for Chinese and U.S. women, respectively, for the same time. Because surveys showed that virtually no women (in the county) smoked tobacco products, other sources of potent exposure must have contributed to these troubling rates. Analyses of indoor air and blood samples from the women indicate that fuel burning inside the home was largely responsible for the lung cancers. The U.S. EPA studies found a strong association between the existence of lung cancer in females and the duration of time spent cooking food indoors. The levels of carcinogenic compounds present in smoky coal (a local type of coal that smokes copiously) were found to be much higher in the women who used smoky coal for cooking (42)(43).

Since the 1980s, a number of studies examining the relationship between ambient air pollution and health effects in China have been conducted. It is important to remember that although the studies measured only ambient air pollution levels, in reality people are exposed to a combination of indoor and outdoor air. One of most definitive of these studies examined the relationship between air pollution and mortality in two residential areas of Beijing. According to this study, the risk of mortality was estimated to in-

Air Pollution's Toll

TABLE CHINA.2 Estimates of Respiratory Damage That Could Be Avoided by Meeting Class 2 Air Quality Standards in China

PROBLEM	NUMBER OF CASES AVERTED
Urban air pollution	
Premature deaths	178,000
Respiratory hospital admissions	346,000
Emergency room visits	6,779,000
Lower respiratory infections or child asthma	661,000
Asthma attacks	75,107,000
Chronic bronchitis	1,762,000
Respiratory symptoms	5,270,175,000
Restricted activity days (years)	4,537,000
Indoor air pollution	
Premature deaths	111,000
Respiratory hospital admissions	220,000
Emergency room visits	4,310,000
Lower respiratory infections or child asthma	420,000
Asthma attacks	47,755
Chronic bronchitis	1,121,000
Respiratory symptoms	3,322,631,000
Restricted activity days (years)	2,885,000

Source: The World Bank, *Clear Water, Blue Skies: China's Environment in the New Century* (The World Bank, Washington, D.C., 1997), Table 2.1, p. 19.

Air Quality May Be Worse Indoors

TABLE CHINA.3 Indoor Particulate Air Pollution from Coal Burning in China (Sample Studies)

PLACE	URBAN/ RURAL	PARTICULATES (micrograms per cubic meter)
Shanghai	Urban	500–1,000
Beijing	Urban	17–1,100[a]
Shenyang	Urban	125–270
Taiyuan	Urban	300–1,000
Harbin	Urban	390–610[a]
Guangzhou	Urban	460
Chengde	Urban	270–700[a]
Yunnan	Rural	270–5,100
Beijing	Rural	400-1,300
Jilin	Rural	1,000–1,200[a]
Hebei	Rural	1,900–2,500
Inner Mongolia	Rural	400–1,600[a]

Source: World Health Organization (WHO), *Health and Environment in Sustainable Development: Five Years after the Earth Summit* (WHO, Geneva, 1997), p. 86.

Note: a. Particles less than 10 micrometers in size.

crease by 11 percent with each doubling of SO_2 concentration, and by 4 percent with each doubling of TSP. When the specific causes of mortality were examined, mortality from COPD increased 38 percent with a doubling of particulate levels and 29 percent with doubling of SO_2. Pulmonary heart disease mortality also increased significantly with higher pollution levels. Levels of air pollution measured often exceeded WHO guidelines, particularly in winter when ambient air pollution was exacerbated by indoor fuel burning and climatic conditions. Yet, what was striking is that excess mortality was associated with pollutant levels below WHO guidelines, suggesting that the guidelines cannot be perceived as a safe limit (44).

Respiratory diseases, hospitalization, or doctor visits are often a more sensitive measure of the impact of air pollution on human health than mortality. One recent study confirmed that as concentrations of SO_2 and TSP rose in Beijing, so did visits to the emergency room. This increase in unscheduled hospital visits occurred both when air pollution levels were extremely high (primarily in the winter) and when the levels were below WHO's recommended guidelines, bolstering studies in developed countries that have shown excess respiratory disease and mortality at lower doses (45). Although Beijing has been the focus of many studies, it has no monopoly on bad air. Chongqing, the largest and most recently declared autonomous zone, has a higher concentration of SO_2 than any of China's five other largest cities (46). A recent study found that several symptoms of compromised health, including reduced pulmonary function and increased mortality, hospital admissions, and emergency room visits, were correlated with higher levels of air pollution in Chongqing (47). A study conducted in another of China's largest cities, Shenyang, estimated total mortality increased by 2 percent with each 100 micrograms per cubic meter increase in SO_2 concentration, and by 1 percent for each 100 micrograms per cubic meter in TSP (48).

Respiratory diseases are not the only health impacts of concern associated with air pollution. Lead exposure, for instance, leads to neurological damage, particularly in children. China has no comprehensive national data on blood-lead levels, a reliable biomarker of exposure, but some studies show that blood-lead levels are far above the threshold associated with impaired intelligence, neurobehavioral development, and physical growth. (The U.S. standard is 10 micrograms per deciliter.) Between 65 and 100 percent of children in Shanghai have blood-lead levels greater than 10 micrograms per deciliter. Those in industrialized or congested areas had levels averaging between 21 and 67 deciliters (49). In Shanghai, prenatal exposures to lead from urban air were associated with adverse development in the children during their first year of life (50).

Water Scarcity, Water Pollution, and Health

China's rapid economic growth, industrialization, and urbanization—accompanied by inadequate infrastructure investment and management capacity—have all contributed to widespread problems of water scarcity and water pollution throughout the country. China has some of the most extreme water shortages in the world. Of the 640 major cities in China, more than 300 face water shortages, with 100 facing severe scarcities (51). As discharges of both domestic and industrial effluents have increased, clean water has become increasingly scarce. The impact of China's dual problem of water scarcity and water pollution exacts a costly toll on productivity. Water shortages in cities cause a loss of an estimated 120 billion yuan (US$11.2 billion) in industrial output each year. The impact of water pollution on human health has been valued at approximately 41.73 billion yuan per year (US$3.9 billion), which is almost certainly an underestimate (52). Although Chinese decisionmakers are increasingly concerned about the damages associated with water pollution, years of neglect and a lack of funding for research have resulted in limited data on water pollution and even fewer epidemiologic studies on the links between water pollution and human health effects.

China has a total of 2,800 billion cubic meters of annually renewed fresh water; the world's most populous country is fourth in the world in terms of total water resources (53). Considering per capita water resources, China has the second lowest per capita water resources in the world, less than one third the world average. Northern China is especially water-poor, with only 750 cubic meters per capita; this geographic region has one fifth the per capita water resources of southern China and just 10 percent of the world average (54).

The distribution of groundwater is similarly skewed: average groundwater resources in the South are more than four times greater than in the North. Dramatic shifts in annual and monthly precipitation cause floods and droughts, which further threaten economic growth.

As surface water quality has worsened, the Chinese have increased their extraction of groundwater to meet water demand. As a result, overextraction of groundwater has become a serious problem in a number of cities including Nanjing, Taiyuan, Shijiazhuang, and Xi'an. Groundwater depletion is most problematic in coastal cities, including Dalian, Qingdao, Yantai, and Beihai, where saltwater intrusion is on the rise (55). Although there is no comprehensive monitoring of China's groundwater, studies suggest that groundwater quality, not just quantity, is severely threatened in many regions. According to one estimate, one half the groundwater in Chinese cities has been contaminated (56).

INDUSTRIAL AND MUNICIPAL WASTEWATER THREATENS CHINA'S WATER QUALITY

Each year, large amounts of pollutants are dumped into China's water bodies from municipal, industrial, and agricultural sources. China is the world's largest consumer of synthetic nitrogen fertilizers (57). As a result of these activities, pollution is widespread in China's rivers, lakes, and reservoirs. Except for some inland rivers and large reservoirs, water pollution trends in China have worsened in recent years, with the pollution adjacent to industrially developed cities and towns being particularly severe (58).

Some of the major threats to water quality stem from inadequate treatment of both municipal and industrial wastewater. In 1995, China discharged a total of 37.29 billion cubic tons of wastewater, not including wastewater from township-and-village enterprises (TVEs), into lakes, rivers, and reservoirs. Approximately 60 percent was released from industrial sources, the rest from municipal. With only 77 percent of industrial wastewater receiving any treatment in 1995, nearly one half of the industrial wastewater discharged failed to meet government standards (59). Industrial discharges usually contain a range of toxic pollutants including petroleum, cyanide, arsenic, solvents, and heavy metals (60).

Although the amount of wastewater discharged from regulated industries has leveled off since the early 1990s, discharges from TVEs and municipal sources have increased rapidly (61). The increase from TVEs can be traced to the rising proportion of total industrial output from these enterprises and to a lack of pollution control over these enterprises because of their widely scattered geographical distribution. In addition, local authorities are reluctant to tighten control over pollution when pursuit of economic benefits is their first goal.

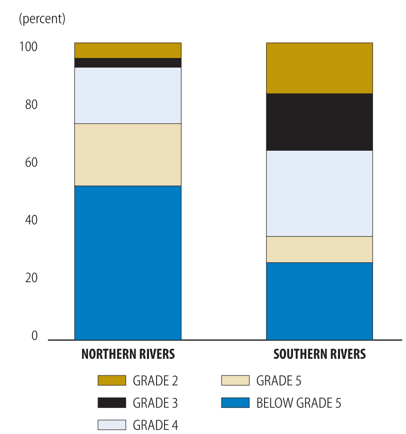
Treatment of municipal sewage lags far behind that of industrial wastewater. In 1995, China had only 100 modern wastewater treatment plants (62). Beijing had only one secondary sewage treatment plant, with a capacity of 500,000 metric tons, which cannot keep pace with the increasing amounts of sewage in the city (63). Treatment should improve rapidly, however, following the amendment of the Water Pollution Prevention and Control Law (64), which set more restrictive regulations, as well as a recent government decision requiring all cities with a population of more than 500,000 to have at least one sewage treatment plant (65).

Water bodies near urban areas are generally the most severely polluted, and the situation is deteriorating. Many urban sections of rivers are polluted by toxic and even carcinogenic compounds, such as arsenic. Although most Chinese attempt to protect themselves from bad water by boiling it, boiling does not affect many of the toxins.

Biological contamination remains a problem as well. Indeed, fecal coliform, mostly from sewage, has become the most challenging drinking water pollutant in the country. In 1994, 54 out of 134 rivers tested did not meet Grade 4 and 5 surface water standards, indicating that the water was deemed unsuitable for even industrial or agricultural use. About 90 percent of the sections of rivers around urban areas were found to be seriously polluted. Because heavy industry is concentrated in northern China, the major river systems in the North are more heavily polluted than those in the South (66). (See Figure China.3.)

Polluted Rivers

FIGURE CHINA.3 Water Quality Is Low at 135 Monitored Urban River Sections, 1995



Source: The World Bank, *Clear Water, Blue Skies: China's Environment in the New Century* (The World Bank, Washington, D.C., 1997), p. 14.
Note: Grades 4 and 5 are deemed unsuitable for direct human contact.

HEALTH IMPLICATIONS

Access to Safe Drinking Water is Key to Protecting Public Health

The health of China's people depends, to a great extent, on the quantity and quality of its drinking water supply. Drinking water quality is largely determined by sources of incoming water, modes of water supply, and the level of water treatment. The majority of Chinese urban and some suburban residents now have access to tap water, while the largest portion of the rural population still relies on hand- or motor-pumped wells, or they fetch water directly from rivers, lakes, ponds, or wells, with little or no treatment at all. Large rivers are the most common source of urban drinking water, as well as the major source for rural residents in many parts of the country.

In only 6 of China's 27 largest cities does drinking water quality meet state standards, according to one recent study. Groundwater did not meet state standards in 23 of these cities (67). The problem is more pronounced in rural China. In some rural areas, the fecal coliform in the drinking water supply exceeds the maximum level by as much as 86 percent; in towns and small cities, the rate is about 28 percent. Currently, around 700 million people in China drink water that fails to meet state standards for fecal coliform (68).

Over the past decade, the government has launched a major initiative to improve access to safe drinking water in rural areas. From 1991 to 1995, the government spent 14.45 billion yuan (US$1.35 billion) to improve the drinking water supply in rural regions (69). Although the rural population with access to tap water more than doubled between 1987 and 1995, when it reached 47 percent, more than one half of those people still drank water that failed to meet safety standards (70).

Infectious Diseases Associated with Poor Water Quality

Despite an overall decline in mortality from infectious diseases in China, the population still suffers from a number of diseases associated with inadequate drinking water quality and sanitation. For the past two decades, diarrheal diseases and viral hepatitis, both diseases associated with fecal pollution, have been the two leading infectious diseases in China. In 1995, the incidence of hepatitis was 63 per 100,000, a 46 percent decrease from 1991. After a sharp drop from 1991 and 1992, the incidence of dysentery has risen since 1994, in part because of the deterioration of water quality. A sudden upswing in the incidence of typhoid fever in 1991 and a large outbreak in some provinces in 1992 were also partly attributed to the poor drinking water quality in rural areas. In 1991, typhoid fever incidence reached as high as 10.6 per 100,000. Although the incidence of waterborne diseases is still high compared with many other countries, effective medical care has kept mortality low, averaging less than 0.1 per 100,000 (71).

It is more difficult to establish the impacts of industrial and chemical water pollution on human health than pollution by human waste. However, recent epidemiological studies suggest that exposure to organic and inorganic chemicals in drinking water may significantly contribute to chronic disease. Liver and stomach cancers are the leading causes of cancer mortality in rural China. Many studies in China and abroad have shown a strong association between drinking water pollution and cancer incidence and mortality. An example is a study conducted in Lujiang County, Anhui Province, where mortality rates for stomach and liver cancers were associated with the high levels of inorganic substances in surface water (72). Although diet and alcohol consumption may play some role in the increases of these cancers, environmental causes cannot be dismissed (73). Since the 1970s, deaths from liver cancer have doubled—China now has the highest liver cancer death rate in the world (74).

In southern China, where some of the population has long depended on ponds for drinking water, the rates of digestive-system cancers are very high. An investigation of 560,000 people in 23 villages and towns showed that between 1987 and 1989, cancer mortality was 172 per 100,000, which is much greater than the average mortality rates in rural China (75). Gastric, esophageal, and liver cancers accounted for 85 percent of all cancers. Other studies reported that the high incidence of liver cancer in Jiangsu's Qidong and Guangxi's Fushun regions is highly correlated with drinking water pollution (76)(77). Further research is needed to confirm this link and identify the specific pollutants at fault.

Impact of Wastewater Irrigation on Health

Irrigation with wastewater has been a common practice in many parts of China throughout its 2,000-year-old agricultural history. In the past several decades, however, the age-old practice of using night soil has been supplemented by the use of industrial wastewater as well, leading to problems with both biological and chemical contaminants. Irrigation with industrial wastes is especially common in the northern regions, where water is scarce. Pollutants, including some organic pollutants, heavy metals, and carcinogens, enter the food chain in the irrigation process and can affect human health.

Numerous studies since the 1970s have shown significant increases in cancer rates and deaths, as well as birth defects, in areas that rely on wastewater for irrigation. For example, research in Shenyang and Fushun showed that the incidence of intestinal infections and enlargement of the liver was, respectively, 49 percent and 36 percent higher in the irrigated areas than in the control area. There were twice as many cancer patients in the sewage-irrigated area. In Fushun, in Liaoning Province, more than 13,000 hectares of farmland are irrigated with water polluted with oil. The adjusted rate of malignant tumor mortality was almost twice that of the control area, and the incidence of congenital malformation was double the rate in the control area (78). Although these associations raise alarms, they do not prove that wastewater is to blame.

Township-and-Village Enterprises: Lack of Regulation Poses Major Threat to Health and Environment

The rapid development of TVEs will have an enormous impact on China's water quality in the coming years. Although their development can be traced back to the late 1950s, these enterprises boomed in the past 10 years. The economic success of the TVEs has reduced poverty for millions of farmers, but they have also inflicted severe damage on the environment in rural China. Even though the Chinese Government has enacted a number of laws and policies to control and regulate industrial discharges (79), the government has not yet effectively regulated TVEs (80).

By 1995, more than 7 million TVEs existed throughout China, with a total output of 5.126 trillion yuan (US$671 billion), accounting for 56 percent of the total industrial GDP—considerably more than the contribution of state-owned enterprises. The number of TVEs is expected to continue to grow. A conservative estimate holds that the TVEs discharge more than half of all industrial wastewater in China—more than 10 billion metric tons. Most TVEs have no wastewater or hazardous waste treatment facilities, and since TVEs are widely scattered across vast rural areas, wastes from TVEs have the potential to affect the health of many people (81).

A 1989–1991 investigation of the 10 leading TVE industries in seven provinces and municipalities showed that industrial wastes were discharged without any treatment and control. An analysis of the health of 860,000 people in the area revealed that the incidence rate of chronic diseases was between 12 and 29 percent, much higher than the national average for rural areas, which is approximately 9 percent. The total mortality in polluted areas averaged 4.7 per 1,000, higher than the average 3.6 in the control area. Life expectancy in the polluted areas was 2 years lower than in the control area. Although not definitive, evidence suggests that industrial pollution from TVEs could become a major threat to human health in China (82).

Laws and Policies to Protect the Environment and Health

China's achievements in health and life expectancy over the past four decades have far exceeded what could be expected for a country at its stage of economic development, according to a recent World Bank evaluation. Behind these dramatic gains in public health was an extraordinary campaign for the Chinese people carried out by the central government, which provided family planning, childhood immunization, accessible primary health care (particularly for mothers and children), improved nutrition, infectious disease control, better education, and improvements in housing and sanitation. (See Table China.4.) Morbidity and mortality from infectious diseases continue to decline on average in most areas of China, although in remote and poor regions, the levels of communicable disease remain much higher than the national averages. The overall success of these programs can be attributed to the central government's approach of adopting the best of traditional methods and wedding these with modern methods. For instance, a campaign to eradicate major public health scourges, such as diphtheria and syphilis, succeeded in large part because it involved vast numbers of traditional doctors in the rural areas (83).

Along with rising income and improved literacy rates, the era of reform has brought more environmental awareness to the Chinese people. A few recent studies in China showed that as communities have become wealthier and better educated, the public has begun to push for stronger regulations and enforcement (84). The increase in media coverage of pollution accidents has contributed to the public's awareness. A popular saying in China's developed eastern region is, "The house is new, the money is enough, but the water is foul and the life is short" (85).

How will China set priorities to prevent environmental exposures and protect public health? Although the government has already begun to address particulate and SO_2 emissions, much remains to be done. While regulatory standards will likely reduce emissions from power plants and state-regulated industries, smaller residential sources and TVE industries will continue to threaten air quality. Residential coal burning for cooking and heating will continue to be a major source of exposure until there is more universal adoption of cleaner fuels. Even though the government has focused some attention on mobile source pollution, it will be a difficult problem to address, given the rapid expansion of the fleet of vehicles.

Most Chinese Have Safe Water and Sanitation

TABLE CHINA.4 Access to Safe Drinking Water and Sanitation Among Selected Countries in Asia, 1990

	PERCENTAGE OF THE POPULATION WITH ACCESS TO					
	SAFE DRINKING WATER			SANITATION [a]		
COUNTRY	URBAN	RURAL	TOTAL	URBAN	RURAL	TOTAL
China	87	68	72	100	81	85
India	86	69	73	44	3	14
Indonesia	35	33	34	79	30	45
Sri Lanka	80	55	60	68	45	50
Japan	100	85	96	100	100	100

Source: The World Bank, *Clear Water, Blue Skies: China's Environment in the New Century* (The World Bank, Washington, D.C., 1997), Table 2.2, p. 20.

Notes: a. Assumes that residents have access to water for washing and that sewage is removed from the house through outdoor latrines, night-soil collection systems, or flush toilets.

ENVIRONMENTAL LAWS AND REGULATIONS

Since the promulgation of the Environmental Protection Law in 1979, the first of its kind in China, 5 pollution-control statutes and 10 natural resource conservation statutes have been enacted. The Environmental Protection and Natural Resources Conservation Committee of the National People's Congress, the lawmaking arm, submitted a 5-Year Legislative Plan to the National People's Congress in 1993. According to the plan, approximately 7 key environment and natural resource statutes will be created or amended by 1998, and more than 17 such statutes will be created or amended by the end of this century. The United States, by comparison, has passed approximately 21 major environmental acts in the last four decades.

The Energy Conservation Law was passed on November 1, 1997, and came into force on January 1, 1998. The scope of this law extends to energy from coal, crude oil, natural gas, electric power, coke, coal gas, thermal power, biomass power, and other energy sources. This law may be the harbinger of strengthened efforts by the Chinese Government to prohibit certain new industrial projects that seriously waste energy and employ outmoded technologies.

Despite the complex system of legislative and policy tools in place and the network of environmental officials throughout China, compliance with environmental regulations remains low, essentially because economic development remains the country's priority at all levels of society.

As part of its efforts to strengthen environmental law enforcement, the government revised its criminal code to punish violations against the environment and resources. This step may provide law enforcement agencies with some power. However, the vagueness of standards in many laws and regulations, coupled with the lack of a comprehensive enforcement regime, has led to a situation where many environmental laws still reflect deals cut between the local environmental protection agencies, NEPA, other ministries, local government bodies, and the polluting enterprises. Thus, the degree of actual compliance and enforcement depends on the region concerned and the personalities involved. Often, the richer the potential investor, the more strictly environmental policy will be applied (86).

For the next decade or so, China's rapid development will likely lead to further uncertainty in the regulatory regime. In the meantime, an increasing array of resources are being devoted to enforcement, and discussions are currently underway to elevate NEPA to ministerial status, which may give NEPA more leverage and authority in law enforcement. Nonetheless, many Chinese officials adamantly hold that economic development must come before environmental protection. They also disagree about how stringent environmental initiatives need to be to protect the health of billions of citizens while maintaining economic growth. This internal struggle enhances the paradoxical quality of Chinese environmental law, which may at once appear both simple and complex, or lenient and severe (87).

USING ECONOMIC INSTRUMENTS—HARNESSING THE MARKET

In its transition from a command to a market economy, China is trying to harness the market to work for the environment rather than against it. Continued and accelerated economic reform is a prerequisite to reorient state enterprises so that they respond to environmental penalties. Liberating international trade will give Chinese industry access to the latest environmental technology. The development of capital markets is necessary to provide financing to firms and municipalities supplying environmental infrastructure. Adjustments of the pricing system are needed to ensure that it reflects true environmental costs.

Despite the fact that China is resource-poor, it prices its energy and water far lower than the actual costs. However, great strides are being made to rectify this situation. Over the past 3 years, the government has raised and partly deregulated coal prices; in most areas, coal prices now cover the costs of production and delivery. In addition, many cities and provinces are currently preparing to increase sewage and water charges to consumers and industries. In Taiyuan of Shanxi Province, for instance, the price bureau has announced that water prices will quadruple over the next 5 years in order to recover supply costs (88). Shanghai recently increased tap water prices by between 25 and 40 percent to fund water quality improvement programs and to make sewage self-financing. Guangzhou and Chongqing are eager to do the same (89).

The increasing market orientation of the industrial sector offers an opportunity to use market-based pollution controls more effectively. Achieving pollution control objectives will require increasing pollution charges. NEPA has proposed a 10-fold increase in the air pollution levy; this increase would go a long way toward reducing air pollutant emissions. Higher levies are needed both to lower current emissions and to finance the large investment required to achieve desired ambient air quality in Chinese cities. Currently, the pollution levies are assessed only on discharges that exceed the standard; in other words, emissions cost the polluter nothing until the standards are breached. Moreover, effluent charges are based on the pollutant that exceeds the standard by the greatest amount and do not reflect the risks posed by other pollutants. The World Bank has been working with NEPA to overcome these shortcomings. These two organizations are developing a system that incorporates both maximum discharge rates for all pollutants as well as incentives to encourage emissions at levels below the maximum allowed (90).

INCREASING ENVIRONMENTAL INVESTMENT

Environmental protection demands more spending. The Chinese Government has attributed the continued deterioration of the environment largely to lack of funding. Despite extremely ambitious 5-year plans to control environmental pollution in the past, insufficient investment has prevented realization of these goals. Now in its Ninth 5-Year Plan period, the government has adopted the Trans-Century Green Plan, which sets targets for environmental protection for the year 2010. In conjunction with other environmental protection plans, NEPA is striving to stabilize the emissions of several pollutants at 1995 levels by the year 2000. The percentage of SO_2, particulates, untreated sewage, and heavy metals sewage treated would be increased from its current 19 percent to 25 percent, and treatment of industrial wastewater would be expanded by about 70 million metric tons. This ambitious plan, which NEPA estimates will cost 450 billion yuan (1.3 percent of China's GNP) to achieve, accords top priority to certain areas, especially along the east coast and in some parts of its inner land: the Hai, Huai, and Liao rivers; the Chao, Dianchi, and Tai lakes; and two areas in southwest China with pronounced problems with SO_2 levels and acid rain (91).

Industries and local governments are increasingly looking for new sources of funding, through the "polluter pays" principle, urban environmental infrastructure funds, and even bank loans. The central government is playing a more supportive role in seeking loans and foreign investment and implementing economic policies. The government intends to increase the proportion of GNP spent on controlling pollution from the current 0.8 percent to more than 1 percent at the turn of the century, or approximately 188 billion yuan (US$17.5 billion) (92). Some cities are investing in an even higher proportion. For instance, Beijing, Shanghai, and Xiamen have decided to allocate up to 3 percent of their GDP to pollution control. Tianjin will set aside up to 2 percent (93). In the meantime, China also hopes that foreign investment will continue to provide funds supporting its ambitious plans to address pollution. A recent World Bank report noted that investing about 1 percent of GDP each year gradually rising to 2.5 percent over the next 25 years—divided roughly equally between air and water investment—would greatly reduce pollution in China by 2020 (94). The report also noted that the operating and the average investment costs each year of such a program would gradually rise to about 2.5 percent of GDP by the end of the period. According to the World Bank, the benefits of these measures exceed the costs by large margins, and these measures are essential if China is to redirect its development toward a more sustainable path.

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References and Notes

1. The World Bank, *World Development Indicators 1997*, on CD-ROM (The World Bank, Washington, D.C., 1997).
2. Jonathan Sinton, ed., *China Energy Databook*, *1996 Revision* (University of California at Berkeley, Berkeley, 1996), p. x-12.
3. International Labour Organization (ILO), *Economically Active Population, 1950–2010: Vol. 1, Asia* (ILO, Geneva, 1996), p. 205.
4. The World Bank, *World Development Indicators 1997* (The World Bank, Washington, D.C., 1997), p. 130.
5. International Energy Agency, *Energy Statistics and Balances: Non-OECD Countries, 1971–1995*, on diskette (Organisation for Economic Co-Operation and Development, Paris, 1997).
6. United Nations (U.N.) Population Division, *Urban and Rural Areas 1950–2030 (The 1996 Revision)*, on diskette, (U.N., New York, 1997).
7. Li Junfeng *et al*., *Energy Demand in China: Overview Report*, Issues and Options in Greenhouse Gas Emissions Control Subreport Number 2 (The World Bank, Washington, D.C., 1995), p. 17.
8. China Ministry of Public Health, *Selected Edition on Health Statistics of China 1991–1995* (China Ministry of Public Health, Beijing, 1996), p. 3.
9. Chen Junshi *et al*., *Diet, Lifestyle, and Mortality in China: A Study of the Characteristics of 65 Chinese Counties*, published in the U.K. by Oxford University Press, Oxford; in the United States by Cornell University Press, Ithaca; and in China by the People's Medical Publishing House, Beijing (Oxford University Press, Oxford, 1990), p. 73.
10. National Environmental Protection Agency (NEPA), *1996 Report on the State of the Environment* (NEPA, Beijing, 1997) (Chinese language edition).
11. Qian Chen, "Improve the Eco-Environment and Rebuild the Beautiful Mountains and Rivers," *China Environment News* (September 13, 1997), p. A.
12. The World Bank, *Clear Water, Blue Skies: China's Environment in the New Century* (The World Bank, Washington, D.C., 1997), p. 23.
13. *Op. cit.* 10.
14. Zhang Jianguang, "Environmental Hazards in the Chinese Public's Eyes," *Risk Analysis*, Vol. 14, No. 2 (1994), p. 165.
15. Outlined in National Environmental Protection Agency (NEPA), *The National Ninth 5-Year Plan for Environmental Protection and the Long-Term Targets for the Year 2010* (NEPA, Beijing, 1996).
16. Fang Cai, "Stare Into the Sky—When Will It be Clear?," *China Environment News* (January 21, 1997), p. 1.
17. National Environmental Protection Agency (NEPA), *National Environmental Quality Report, 1991–1995* (NEPA, Beijing, 1996), pp. 5, 15.
18. *Op cit.* 12, pp. 8–9.
19. China Environment Yearbook, *China Environment Yearbook*, various issues (China Environment Yearbook Press, Beijing, various years) (Chinese language editions).
20. International Energy Agency, *Energy Statistics and Balances: Non-OECD Countries, 1971–1995*, and *Energy Statistics and Balances: OECD Countries, 1960–1995*, both on diskette (Organisation for Economic Co-Operation and Development, Paris, 1997).
21. *Op. cit.* 2, p. iv-11.
22. *Op. cit.* 19.
23. *Op. cit.* 7, p. 43.
24. *Op. cit.* 2, p. viii-2.
25. *Op. cit.* 12, pp. 21–22, map 1.
26. *Op. cit.* 12, pp. 8, 46.
27. *Op. cit.* 2, p. v-4.
28. American Automobile Manufacturers Association (AAMA), *Motor Vehicle Facts and Figures* (AAMA, Washington, D.C., 1996), pp. 44–47.
29. Stephen Stares and Liu Zhi, "Motorization in Chinese Cities: Issues and Actions," in *China's Urban Transport Development Strategy: Proceedings of a Symposium in Beijing, November 8–10, 1995*, World Bank Discussion Paper No. 352 (The World Bank, Washington, D.C., 1996), p. 50.
30. Liu Xianshu and Xiao Yunxiang, "How to Enjoy and Use Automobiles," *China Environment News* (January 28, 1997), p. 1.
31. Michael Walsh, "Motor Vehicle Pollution in China: An Urban Challenge," in *China's Urban Transport Development Strategy: Proceedings of a Symposium in Beijing, November 8–10, 1995*, World Bank Discussion Paper No. 352 (The World Bank, Washington, D.C., 1996), pp. 118–122.
32. He Kebin *et al*., "The Status and Trend of Urban Vehicular Pollution," *Environmental Science*, Vol. 17, No. 4 (1996), pp. 80–83 (in Chinese).
33. He Kebin *et al*., "Status and Developments in China's Vehicle Emissions Pollution," *Environmental Science*, Vol. 7, No. 4 (1996), pp. 15–17 (in Chinese).
34. *Ibid.*
35. *Op. cit.* 31, p. 120.
36. *Op. cit.* 12, pp. 17–18.
37. *Op. cit.* 12, Table 2.1, p. 19.
38. World Health Organization (WHO), *Health and Environment in Sustainable Development: Five Years After the Earth Summit* (WHO, Geneva, 1997), p. 82.
39. *Ibid.,* pp. 83–86.
40. *Op. cit.* 12, p. 19.
41. *Op. cit.* 12, p. 19.
42. Robert S. Chapman *et al*., "Assessing Indoor Air Pollution Exposure and Lung Cancer Risk in Xuan Wei, China," *Journal of the American College of Toxicology*, Vol. 8, No. 5 (1989), pp. 941–948.
43. Judy L. Mumford *et al*., "DNA Adducts As Biomarkers for Assessing Exposure to Polycyclic Aromatic Hydrocarbons in Tissues from Xuan Wei Women with High Exposure to Coal Combustion Emissions and High Lung Cancer Mortality," *Environmental Health Perspectives*, Vol. 99 (1993), pp. 83–87.
44. Xu Xiping *et al*., "Air Pollution and Daily Mortality in Residential Areas of Beijing, China," *Archives of Environmental Health*, Vol. 49, No. 4 (1994), pp. 216–222.
45. Xu Xiping, Li Bauluo, and Huang Huying, "Air Pollution and Unscheduled Hospital Outpatient and Emergency Room Visits," *Archives of Environmental Health*, Vol. 103, No. 3 (1995), pp. 286–289.
46. China Environment Yearbook, *China Environment Yearbook, 1996* (China Environment Yearbook Press, Beijing, 1997), p. 193 (Chinese language edition).
47. *Op. cit.* 12, p. 18.
48. Xu Zhaoyi *et al*., "The Effect of Air Pollution on Mortality in Shenyang City," *Journal of Public Health in China*, Vol. 15, No. 1 (1996), p. 61.
49. *Op. cit.* 12, p. 20.
50. Shen Xiao-Ming *et al*., "Prenatal Low-Level Lead Exposure and Infant Development in the First Year: A Prospective Study in Shanghai, China," paper presented to the International Society for Environmental Epidemiology, University of Alberta, Edmunton, Canada, August 1996.
51. *Op. cit.* 10.
52. *Op. cit.* 12, pp. 23, 87–88.
53. See Data Table 12.1.
54. *Op. cit.* 12, p. 88.
55. *Op. cit.* 10.
56. Zhang Weiping *et al*., eds., *Twenty Years of China's Environmental Protection Administrative Management* (China Environmental Sciences Press, Beijing, 1994), pp. 215–217.
57. Food and Agriculture Organization of the United Nations (FAO), *FAOSTAT Statistical Database* (FAO, Rome, 1996–1997).
58. Vaclav Smil, "China Shoulders the Cost of Environmental Change," *Environment*, Vol. 39, No. 6 (1996), p. 33.
59. *Op. cit.* 10.
60. *Op. cit.* 46.
61. *Op. cit.* 10.
62. China Environment Yearbook, *China Environment Yearbook, 1996* (China Environment Yearbook Press, Beijing, 1997), p. 215 (English language edition).
63. Xiaoke Jiang, Former Director, Beijing's Environmental Protection Bureau, Beijing, 1998 (personal communication).
64. The Water Pollution Prevention and Control Law, initially adopted in 1984, was amended in 1996.
65. This is a decision announced at the 4th National Conference on Environmental Protection, which was convened in Beijing in September 1996.
66. *Op. cit.* 10.
67. Vaclav Smil, *Environmental Problems in China: Estimates of Economic Costs*, East-West Center Special Report No. 5 (East-West Center, Honolulu, 1996), pp. 2, 24.
68. Cai Shiwen, "China's Environmental Pollution and Health Problem," paper presented at the Second Conference of the China Council of International Cooperation and Development, Beijing, 1993.
69. China Ministry of Public Health, *China Yearbook of Public Health 1996* (People's Medical Publishing House, Beijing, 1997), pp. 416–417.
70. Zhang Feng *et al.,* "Status and Analysis of Rural Drinking Water Quality," *Journal of Hygiene Research*, Vol. 26, No. 1 (1997), pp. 30–32.
71. China Ministry of Public Health, *Selected Edition on Health Statistics of China, 1991–95* (China Ministry of Public Health, Beijing, 1996), pp. 69–70.
72. Guili Chen, "The Warning of Huai River," *Contemporary Magazine*, Vol. 2 (1996).
73. Howard Frumpkin, "Cancer of the Liver and Gastrointestinal Tract," in *Textbook of Clinical Occupational and Environmental Medicine* (W.B. Saunders Co., Philadelphia, 1994), p. 576.
74. Feng Rukang, "China Maps Out Geographical Belt of Liver Cancer," *China Environment News* (October 15, 1997), p. 8.
75. Su Delong, "Drinking Water and Liver Cancer," *Journal of Chinese Preventative Medicine*, Vol. 14, No. 2 (1990), pp. 65–73.
76. Liang *et al*., "Epidemiologic Investigation of Relationships Between Drinking Water Types and Liver Cancer," *Cancers*, Vol. 6, No. 3 (1987), p. 177 (in Chinese).
77. Tang He and Lin Nianfeng, "The Relationship Between Organic Water Pollution and Liver Cancer at Fushui in Guangxi," *Journal of Environment and Health*, Vol. 12, No. 5 (1995), pp. 193–195 (in Chinese).
78. Yuan, "Etiologic Study of High Stomach Cancer Incidence Among Residents in Wastewater Irrigated

Areas," *Environmental Protection Science*, Vol. 19, No. 1 (1993), pp. 70–73 (in Chinese).

79. Such policies include pollution levies and permits.
80. Cao Fenzhong, "Air and Water Pollution Problems in TVEs," a policy paper prepared for the Chinese National Environmental Protection Agency (NEPA) (NEPA, Beijing, 1997), p. 1.
81. *Ibid.,* pp. 1–5.
82. Xu Fang *et al.,* "Economic Analysis and Countermeasure Study of TVEs Pollution's Damage to Human Health," *Journal of Hygiene Research*, Vol. 21, Supplement (1992), pp. 1–23.
83. "Decision on Public Health Reform and Development by the Central Committee of the Chinese Communist Party and the State Council," *People's Daily* (February 18, 1997, Beijing), p. 1.
84. *Op. cit.* 12, p. 13.
85. *Report of the 4th National Conference on Environmental Protection* (China Environmental Sciences Press, Beijing, 1996), p. 32.
86. *Op. cit.* 83.
87. Richard J. Ferris Jr., "The People's Republic of China: An Environmental Law Briefing for Corporate Council," *The Metropolitan Corporate Counsel* (December 1997), p. 13.
88. *Op. cit.* 12, pp. 95–96.
89. Shuping Lu, Director, Shanghai Environmental Protection Agency, 1998 (personal communication).
90. Dr. Hua Wang, Consultant and Principal Economist in the Environment, Infrastructure, and Agriculture Division, Policy Research Department, The World Bank, Washington, D.C., 1997 (personal communication).
91. *Op. cit.* 15, p. 12.
92. *Op. cit.* 15, p. 4.
93. Wang Yi, Professor/Senior Scientist, Eco-Environment Research Center of the Chinese Academy of Sciences, 1997 (personal communication).
94. The World Bank, *Can the Environment Wait? Priorities for East Asia* (The World Bank, Washington, D.C., 1997), p. 1.