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Contemporary threats and air pollution

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A B S T R A C T

It is now well understood that air pollution produces significant adverse health effects in the general public and over the past 60 years, there have been on-going efforts to reduce the emitted pollutants and their resulting health effects. There are now shifting patterns of industrialization with many heavily polluting industries moving from developed countries with increasingly stringent air quality standards to the developing world. However, even in decreasing concentrations of pollutants, health effects remain important possibly as a result of changes in the nature of the pollutants as new chemicals are produced and as other causes of mortality and morbidity are reduced. In addition, there is now the potential for deliberate introduction of toxic air pollutants by local armed conflicts and terrorists. Thus, there are new challenges to understand the role of the atmospheric environment on public health in this time of changing economic and demographic conditions overlaid with the willingness to indirectly attack governments and other established entities through direct attacks on the general public.

1. Introduction

Although it has not had the priority it does today, air pollution has been recognized as a problem throughout history. King Tukulti, an Egyptian king, visited Hit in 900 BC and reported a strange smell in the air. According to Egyptian historical records, when Nubian troops enclaved the city of Hermopolis, which is situated on the left bank of the Nile half-way between Theba and Memphis, the inhabitants rather surrendered pleading for mercy, than to further bear the smell of their own town air (Brimblecombe, 1995). Seneca reported in 61 AD that he felt much better once he left the confines of Rome. The first significant air pollution regulations were promulgated in 1306 by In King Edward when he banned coal burning in England with the penalty being “grievous ransom” meaning significant fines. King Edward’s mother, Queen Eleanor, was made so sick by the coal fumes wafting up from the town below that she had to flee Nottingham Castle. Controls on industry were suggested in 1661 by John Evelyn (1995) in which he suggested moving industries from urban areas. With the beginning of the Industrial Revolution in the 19th century, air pollution increased such that Sir Conan Doyle describes the dense “fogs” in London that obscure the view of London as described by Dr. Watson in his tales of Sherlock Holmes.

In 1930 in Meuse Valley, Belgium, the 15-mile valley trapped pollutants released by coke ovens, steel mills, blast furnaces, zinc smelters, glass factories, and sulfuric acid plants leading to 63 deaths and 600 made sick. The first identified photochemical smog episode was in Los Angeles in 1943. Another air pollution catastrophe occurred in 1948 in Donora, Pennsylvania with 6000 illnesses ranging from sore throats to nausea and 20 deaths in three days.

However, air pollution really came to public attention with the London fog episode of December 1952 in which thousands of excess deaths have been attributed to the dense fog of SO_2 and particles. This event led to legislation and regulation that over the past 50 years, has produced significant improvements in air quality with concomitant decreases in health effects and ecological damage. The experience in the United Kingdom is presented by Longhurst et al. (2009). In the United States, the ineffective Clean Air Act of 1963 was enhanced by a series of amendments in 1970, 1977 and 1990 that has led to substantial improvements in air quality and significant benefits to the U.S. (US EPA, 1997). This approach is projected to continue to produce significant benefits for the U.S. public through 2012 (US EPA, 1999) and a review through 2020 is currently under review (http://www.epa.gov/air/sect812/prospective2.html).

During the past 50 years, important changes have occurred in the nature of industrial production around the world with most of the low skill level manufacturing moving from developed countries to developing economies where lower cost labor and less stringent emissions standards has provided reduced production costs. Even with the costs of transportation added to the costs, the goods can be sold in Europe and North America for lower prices. Thus, a shift in emissions is occurring from developed to developing countries. In addition, new sources of air pollution have arisen as deliberate emission of toxic, biological, or radioactive material as a result of

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Table 1
Estimated 1995 emissions of mercury (tons per year) (Pirrone et al., 2001).

Continent	Stationary combustion	Non-ferrous Metal production	Pig iron and steel production	Cement production	Waste disposal	Total, quantified sources
Europe	185.5	15.4	10.2	26.2	12.4	249.7
Africa	197.0	7.9	0.5	5.2		210.6
Asia	860.4	87.4	12.1	81.8	32.6	1074.3
North America	104.8	25.1	4.6	12.9	66.1	213.5
South America	26.9	25.4	1.4	5.5		59.2
Australia and Oceania	99.9	4.4	0.3	0.8	0.1	105.5
Total, quantified sources, 1995	1474.5	165.6	29.1	132.4	111.2	1912.8

war or terrorist acts. Thus, in the future, there are a changing array of possible threats to air quality posing new risks for human and environmental health and climate.

2. Shifting patterns of air pollution

To illustrate the resulting change in emissions, Smith et al. (2001) report that globally, SO_2 emissions have been roughly constant from 1980 to the present. In 1980, 60% of global emissions were from around the North Atlantic basin, but by 1995, this region contributed less than 40% of the global total and will contribute even less in the future. For mercury, Pirrone et al. (2001) provide the emissions presented in Table 1. It can be seen that the Asian region produces the largest mercury emissions. Table 2 from Wu et al. (2006) suggests that the Hg emissions from China have continued to grow from 1995 to 2003 at rates of approximate 3% per year with a substantial part of this growth being from non-ferrous metal production and coal-fired power plants. Wong et al. (2006) suggest that anthropogenic Hg emissions across Asia have been underestimated and continued increases are likely to offset the reductions implemented in North America and Europe.

The rapid economic growth has led to increasing use of fossil fuels and produced a concomitant release of CO_2. Estimates of historic record of CO_2 emissions up to 2004 have been developed for every country (CDIAC, 2008). Fig. 1 shows the estimated emissions from the United States, China and India from 1940 to 2004. The rapid rise in the Chinese emissions in the most recent years can be seen. Auffhammer and Carson (2008) used the available data to forecast the future CO_2 emissions. They estimate that China's emissions now exceed those of the United States and much larger than the existing estimates for these emissions. These increased emissions are much larger than the level of decreases that were embodied in the Kyoto Protocol so that the projected reductions by developed countries will be overwhelmed by the increased emissions from China. It can be seen that Indian emissions are also rising rapidly so it will take a more comprehensive strategy to permit the real control in the growth of global greenhouse gas emissions. A similar pattern of rapid growth can be seen in a number of developing nations as their economies begin to grow.

There are not many published reports of measured pollutant concentrations across the Asian region. There are emissions estimates such as Gurjar et al. (2008) that suggest substantial air quality problems in large urban areas ("megacities") with Dhaka, Beijing, and Karachi requiring the most urgent reductions in emissions.

Fang et al. (2005) have reviewed the available data for metallic elements measured across Asia during the period of 2000–2004. This review paper summarizes data from a number of studies that measure particulate matter. However, the measurements are made with multiple collection devices for particles in different size ranges and analyzed by a variety of analytical methods. Much of the available data are for TSP at a time when the focus of much of the

Table 2
Summary of Mercury Emissions in China by Industrial Sector 1995-2003 (Table from Wu et al., 2006).

Source Category	1995	1996	1997	1998	1999	2000	2001	2002	2003	AAGR[a]
Coal Combustion	202.4	209.3	208.2	207.6	202.2	204.3	208.8	225.5	256.7	3.00%
1. power plants	63.4	68.7	67.2	66.2	67.8	70.1	76.3	84.2	100.1	5.90%
2. industrial use	104.7	106.3	107.8	108.3	103.2	104.2	101.9	109.9	124.3	2.20%
3. residential use	23.1	23.5	22.7	21.5	19.7	19.6	19.9	19.7	21.7	-0.80%
4. other uses	11.2	10.8	10.5	11.6	11.5	10.5	10.7	11.8	10.6	-0.70%
Nonferrous metals	230.1	213.1	212.2	213.8	242.4	262.4	281.7	294.6	320.5	4.20%
1. zinc (Zn)	97.6	103.2	125.5	127.8	147.6	161.4	173	178.5	187.6	8.50%
2. copper (Cu)	10.4	10.7	11.3	8.4	10.1	12.7	13.7	14.8	17.6	6.90%
3. lead (Pb)	26.5	30.8	30.9	33	40.1	48	54.3	57.8	70.7	13.00%
4. gold (Au) - large scale	10.1	11.4	16.1	16.1	16.1	11.8	12.3	15	16.2	6.00%
5. gold (Au) - artisanal	85.5	57	28.5	28.5	28.5	28.5	28.5	28.5	28.5	-12.80%
Fuel oil -stationary sources	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	2.30%
Gasoline, diesel and kerosene	4.3	4.6	4.6	5	5.6	6.1	6.4	6.8	7.6	7.20%
Biofuel combustion	10.1	9.1	8.7	8.7	8.3	8.6	9.5	10.6	10.7	0.70%
Grassland/savanna burning[b]	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	0.00%
Forest burning[b]	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	0.00%
Agricultural residue burning[b]	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	0.00%
Household waste burning	0.6	0.6	0.6	2	2	2.8	3.2	7.7	10.4	42.50%
Coal mines- spontaneous burning[b]	3	3	3	3	3	3	3	3	3	0.00%
Cement production	19.9	20.5	21.3	21.4	22.7	23.9	27	29.4	35	7.40%
Iron and steel production	3.8	4.1	4.4	4.6	4.9	5.1	6.1	7.3	8.9	11.20%
Caustic soda production	2.4	2.4	2.5	1.3	0.2	0.2	0.2	0.2	0	N/A
Mercury mining	35.1	22.9	37.6	10.1	8.8	9.1	8.7	22.3	27.5	-3.00%
Battery/fluorescent lamp production	29.1	34.1	49.7	37.6	24.5	16.2	8.7	6.2	3.7	-22.70%
Total	552.2	534.9	564.2	526.4	535.7	553	574.7	625	695.6	2.90%
(a) Hg0	311.7	293.4	317.4	288	299.2	312.2	327.1	357.7	394.9	3.00%
(b) Hg2+	169.2	171.3	176.5	170.8	171.8	177.9	184.8	202	230.3	3.90%
(c) Hgp	71.4	70.2	70.3	67.6	64.7	62.9	62.8	65.3	70.3	-0.20%