Health & Clean Air newsletter

Spring-Summer 2005

Air Pollution and Global Warming:

The Seamless Web

But the Valley grew narrow and narrower still,
And the evening got darker and colder,
Till (merely from nervousness, not from good will)
They marched along shoulder to shoulder.

The Hunting of the Snark, Lewis Carroll

Perhaps it is because some people crave order, or because there are many laws that expressly deal with "air pollution" but almost none to control global warming. Whatever the cause, much of the world seems of the view, incorrectly, that there are, on the one hand, "air pollutants" that kill and injure—smog, soot, and acids, for example—and different toxins, "greenhouse gases," that cause global warming. Yet, as virtually any atmospheric chemist will verify, that is a distinction without a difference.

"Air pollutants" change climate, virtually all of them by causing warming, while "greenhouse gases" increase air pollution. Air pollution kills, so do higher temperatures. Air pollution is emitted by cars, trucks, buses, power plants, and cement kilns, to name but a few; and so, too, are greenhouse gases. Similarly, the technologies and practices that reduce air pollution will do the same with greenhouse gases.

In short, to speak of—or design programs to reduce—*only* air pollution on the one hand or *only* greenhouse gases on the other, is to make a distinction where there is fundamentally no difference, and thus to lay the foundation for failure across the board.[i] Hence, for purposes of this Newsletter, we will avoid the terms air pollution and greenhouse gases and, instead, refer to contaminants or wastes.

Gradually, health and climate scientists alike, understanding that they share a common foe, are allying with one another. And a good thing, too, for the toll being exacted by massive contamination of the air is immense. These wastes are killing not only humans[1], including our children[2], but forests[3] and lakes[4] as well, poisoning soils[5], boosting temperatures[6] thus raising sea levels[7], destroying ecosystems in the polar and temperate regions

[i] There are three contaminants, all engineered chemicals, that cause global warming but seem to have low toxicity. They are hydrofluorocarbons (HFCs), which were developed as substitutes for the ozone-destroying chloroflourocarbons (CFCs); perfluorocarbons (PFCs), emitted in aluminum smelting and uranium enrichment; and, sulphur hexafluoride (SF6), used in magnesium production and as an electricity insulator. While emissions of these three are quite small, they are tremendously potent greenhouse gases, up to 12,000 times as powerful as carbon dioxide, in part because of atmospheric lifetimes of up to 50,000 years. (See USDOE, http://www.eia.doe.gov/oiaf/1605/ggrpt/othergases_tbls.html). Yet another potent greenhouse gas, methyl bromide, is routinely injected into soils around schools and homes, even though it is a "severe pulmonary irritant and neurotoxin" according to the Centers for Disease Control (see http://www.cdc.gov/mmwr/preview/mmwrhtml/00001527.htm) and is said to have killed at least 18 persons in California (Steve Berry, "Illness Probed for Possible Pesticide Link," *Los Angeles Times*, Mar. 22, 1997).

alike[8], shifting populations of animals and plants[9], spurring the spread of malaria, dengue fever and other diseases[10], and altering fundamental parameters of the planet that have remained unchanged for scores of centuries.[11]

Our air is awash in chemicals, most of which have no business being there.[12] Only a handful, however, account for virtually all known damage. There are essentially three sources of these wastes: the air itself; the fuel that is being burned; and, time during which the wastes initially emitted cook in the atmosphere, forming completely new, and often more dangerous, contaminants.

Start Your Engines, and Run for Cover

Shovel coal into a furnace or crank the engine on your car and almost instantly fumes will start pouring out. These are the first, or primary, pollutants. Except for a few, all damage both human health and alter the climate.

If the carbon in the coal and gasoline burns completely, carbon dioxide will rush from the smokestack or exhaust. If the engine or burner is out of tune, however, the exhaust will be rich in other wastes, especially carbon monoxide, an invisible gas, and black carbon, particles so small that 50 or more can fit on the thickness of a human hair.[13] Many of the particles will be coated with heavy metals, as well as organic chemicals like benzene and dioxins.[14]

HEALTH & CLEAN AIR newsletter

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In addition, virtually all coal and oil—and the fuels made from them, like gasoline and diesel—contain sulfur.[15] So, mixed with the carbon dioxide and monoxide will be sulfur dioxide, another invisible gas, as well as unburnt gasoline or coal vapors, referred to collectively as hydrocarbons. The high temperatures will have caused the oxygen and nitrogen in the air to combine, creating oxides of nitrogen.[16] In modern cars, most of the oxides of nitrogen are quickly destroyed by the catalytic converter. Some, however, will have been changed by the converter into a new pollutant, nitrous oxide, which has a powerful warming effect.[17]

There will be a number of other nasty chemicals as well from coal: mercury, which poisons children and the unborn[18], as well other metals (cadmium, arsenic, etc.) and cancer-causing chemicals, such as benzene; and, extremely toxic compounds, such as dioxin.[19]

As soon as the "primary" wastes reach the air, they begin turning into new, or "secondary," contaminants. Some reactions take minutes, others hours, days or even weeks. The hydrocarbons and oxides of nitrogen form ozone, or smog. If it's a hot day, the smog may form quickly, and rapidly build up on street corners, blanketing urban neighborhoods. But if it's cool, it may take weeks for the ozone to form, during which the oxides of nitrogen may form smog by reacting with methane (better known to most of us as natural gas[20]), which is produced by landfills and sewage treatment plants, as well as cattle and sheep.[21] Then, the ozone may be over rural areas or even in mid-ocean.[22]

Similarly, the sulfur dioxide and oxides of nitrogen will cook in the air, turning into sulfuric and nitric acids or their dry equivalents, fine particle sulfates and nitrates.[23] Eventually, they fall, settling on leaves or the ground—or in lungs.

Finally, the cast of characters is complete, as follows:

The products of incomplete combustion: black carbon and carbon monoxide

The two principal products of incomplete burning are—

- **Black carbon**[24], as it is called by climate scientists, also termed **fine particles**[ii] by health researchers.[25] By either name, they kill humans and increase the Earth's temperature; and,
- **Carbon monoxide**, which kills at high concentrations—for example, when a car is left idling in a first story garage—and also increases the Earth's temperature, though indirectly.[26]

Fine particles billow by the millions of tons each year from gasoline, diesel and jet engines, coal fired power plants, steel mills, and hundreds of other types of smokestacks and tail pipes, literally clouding virtually the entire North American continent. Visibility measurements from airport and other sites reflect concentrations of fine particles. On maps in which dense haze is shown in deepening shades of orange, that color has spread from a small, roughly circular area covering northern Ohio and bordering areas of Pennsylvania and Michigan in 1960 to a blanket over virtually every square mile east of the Mississippi River in 1990.[27] In a few locations—Southern California is the most notable—fine particle levels have fallen, but in other areas—especially developing nations—emissions are increasing rapidly. In a recent study of the Arctic, researchers found that about one-third of the soot there comes from South Asia.[28]

[ii] Some fine particles are composed of nitrate and sulfate, formed from conversion of the gases, sulfur dioxide and oxides of nitrogen. They are discussed separately.

The picture is much the same globally. Using current power-plant and combustion-engine emissions, estimates of past emission rates and records of coal and transport fuel consumption, a team of researchers found that black carbon increased rapidly in the late 1800s, leveled off in the first half of the 1900s, then began to accelerate over the last 50 years.[29] Today, the contribution of black carbon to global warming is substantial, perhaps second only to that of carbon dioxide.[30]

Fine particles: death and illness. As fine particle levels rise, so do hospital admissions, emergency room visits, school absences, chronic bronchitis, heart attack, stroke and death.[31] Globally, estimates of death due to particles range from around 200,000 to 570,000, representing about 0.4 to 1.1 percent of total annual deaths.[32] The estimates are likely to be low, because in the United States, an increase in fine particle air pollution of 10 micrograms per cubic meter results in a 4 percent increase in general morbidity, a 6 percent increase in cardio-pulmonary mortality and an 8 percent increase in lung cancer mortality.[33] Yet the U.S. has vastly cleaner air than many of the cities of the developing world, so death and illness elsewhere are likely to be much higher. Particle levels in Delhi, India, for example, are 187 parts per billion, compared to 38 in Los Angeles, nearly a 500 percent difference.[34]

Black carbon: global warming. Black carbon, or soot, falling on ice and snow, darkens surfaces, absorbing more sunlight and reflecting less, thus accelerating melting.[35] In addition, black carbon can alter the manner in which clouds are formed, reducing their reflection of sunlight.[36]

Although black carbon warms the atmosphere, it is not a "greenhouse gas." It is a solid, not a gas. Moreover, greenhouse gases like carbon dioxide, methane and ozone, warm by absorbing infrared radiation. (Infrared is created when sunlight from nuclear explosions on our sun, races through space and passes easily through the Earth's atmosphere. Then it strikes the Earth's surface, which converts it from light energy to infrared. As the infrared attempts to radiate upwards, it is blocked by the greenhouse gases, so the heat is trapped, warming the atmosphere.[37] In contrast, black carbon warms by absorbing the inbound sunlight.[38])

Because the way in which the Earth is warmed by black carbon differs from that of waste gases, it may have climate effects other than warming. One team of scientists has concluded, for example, that black carbon emissions in China and India may have caused the increase in droughts in northeast China and summer flooding in southeast China during the last 20 years.[39]

There can be no question that levels of this waste, whether termed black carbon or fine particles, have sharply increased by human activity and are heading even higher, on both regional and global scales.

Carbon monoxide, an invisible and odorless gas, kills at high concentrations. Oxygen in the blood is carried from the lungs to the rest of the body by hemoglobin, which absorbs, then releases the life-giving gas. Carbon monoxide, however, has an affinity for hemoglobin 220 times as powerful as oxygen, so the gas essentially kills by starving large organs—or, if the victim is a pregnant women, her fetus—of oxygen.[40] One of the consequences is an increase in babies born with low birth weight.[41] Not surprisingly, as levels of carbon monoxide rise, so do heart attacks,[42] and deaths among those suffering from congestive heart disease.[43]

If the hydroxyl radical were not destroyed by CO, it would eliminate immense amounts of ozone and methane, thus reducing the global warming they cause and their health and environmental damages.

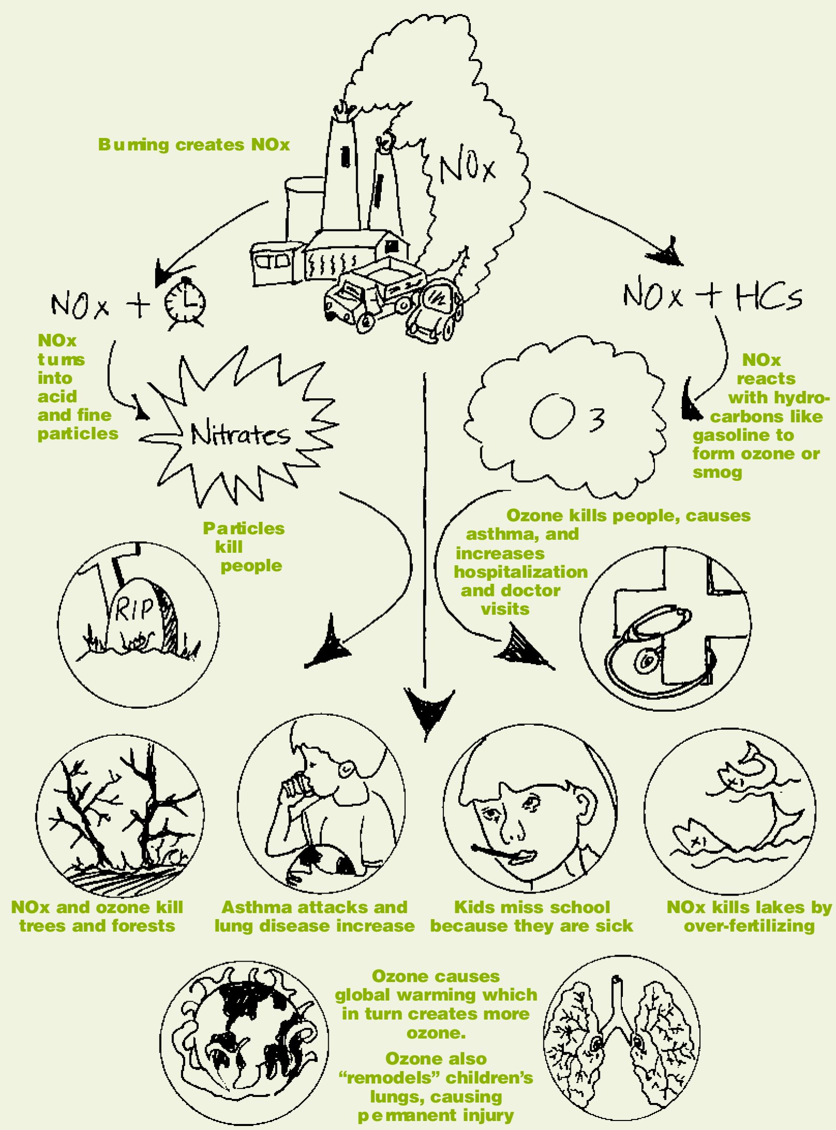
In the air, carbon monoxide destroys the hydroxyl radical, which is sometimes referred to by scientists as the atmosphere's "cleansing agent"[44] because it is the dominant destroyer of methane, volatile organic compounds, oxides of nitrogen and many other atmospheric contaminants. Scientists have examined air trapped in the Greenland permafrost, concluding that from 1300 to 1700, hydroxyl levels were stable, then started falling and by 1989 were off 50 percent.[45] These results are consistent with computer models.[46]

The vast majority of Earth's supply of hydroxyl is destroyed by carbon monoxide: about 2,380 terragrams per year, compared to 477 terragrams eliminated by the second-largest scavenger,[47] methane. Indeed, were it not destroyed by CO, the radical would eliminate immense amounts of both ozone and methane, thus reducing the global warming they cause and their health and environmental damages.

The Gases: Carbon Dioxide, Oxides of Nitrogen, Sulfur Dioxide and Methane

Completely burning a fuel—coal, gasoline or diesel, for example—produces carbon dioxide (by combining the fuel carbon with the air's oxygen), oxides of nitrogen (oxygen plus nitrogen from the air or fuel or both), sulfur dioxide (fuel sulfur with oxygen) and some methane (though most

HOW NITROGEN KILLS WHILE CAUSING GLOBAL WARMING AND ILLNESS



is from landfills, sewage treatment plants, livestock and other sources).

Carbon Dioxide. Carbon dioxide (CO_2) is a colorless, odorless gas. Although the fourth most abundant gas in the atmosphere (after nitrogen, oxygen and argon), it is a tiny percentage—only 0.033 percent—of the air. Still, it is remarkably powerful and concentrations are rising sharply. Before about1800, CO_2 concentration was 275 to 280 parts per million by volume (ppmv). The average value in 1958, when the late Dr. Charles David Keeling of the Scripps Institution of Oceanography[48] took his first measurements at Mauna Loa in Hawaii, was about 315 ppmv. Today, it is 374.9 ppm, or more than one-third higher than pre-industrial levels.[49]

The roughly 0.6 degree Celsius increase in temperature that has already occurred because of global warming[50] has begun to disrupt the Earth's environment. A team of researchers from the United States, Australia, France, Germany, and the United Kingdom compiled the results of over 100 research studies on the effects that recent warming has had on animals and plants throughout the world and published the study in the 28 March 2002 edition of the journal, *Nature*. The results, they wrote, revealed "a coherent pattern of ecological change across systems. Although we are only at an early stage in the projected trends of global warming, ecological responses to recent climate change are already clearly visible."[51]

Unlike most other wastes, CO_2 is not directly toxic but as thermometers rise, so do human ailments. In a New Zealand study, for a 1 degree Celsius increase in temperature, deaths from all causes jumped 1 percent, while those for respiratory illness rose 3 percent.[52] In Beirut, Lebanon, an analysis of the effects of temperature found that when it rose 1 degree Celsius from 27.5 degrees, death increased 12.3 percent.[53] In a Denver study that tracked daily variations in air pollution and temperature from 1993 to 1997, higher temperatures were associated with increased heart attack and congestive heart failure.[54] During the intensely hot summer of 2005 in France, high temperatures killed an estimated 15,000 people.[55]

Sulfur Dioxide. An invisible gas, sulfur dioxide (SO_2) also undergoes a chemical reaction in the atmosphere to form two other pollutants, sulfates and sulfuric acid. Each is uniquely dangerous, and even though disentangling their effects can be challenging, their devastating impacts are clear enough that by 1985 Japan had designated 98,080 severely ill residents as official sulfur dioxide "victims" who receive payments for disability, as well as medical and funeral expenses from a dedicated tax on SO_2.[56]

Asthmatics, especially children, are exquisitely vulnerable to sulfur dioxide,[57-60] and asthma is the leading cause of chronic illness in children.[61] An asthmatic exposed to sulfur dioxide can, within minutes, be doubled over gasping for breath.[62, 63]

Oxides of Nitrogen. Oxides of nitrogen destroy organic matter such as human tissue. Animals exposed to NO_X are less able to ward off bacterial infections and die more often.[64, 65] Their susceptibility to viral infection increases,[66] exposure to high levels of NO_X for weeks causes emphysema-like changes in the lungs of animals.[67] Children aged 12 and younger who are exposed to NO_X have more respiratory illness.[68] Those exposed to high levels of NO_X outdoors had more colds that settled in their chests, chronic wheezing and cough, bronchitis, chest cough with phlegm,and episodes of respiratory illness.[69]

Like SO_2, oxides of nitrogen undergo a chemical reaction in the atmosphere to form two other pollutants, nitrates and nitric acid.

The Transformation Products: Sulfate, Nitrate and Ozone

Sulfate, Nitrate and Their Acids. Hanging in the air for days at a time, exposed to sunlight and other chemicals, sulphur dioxide and oxides of nitrogen turn into fine particle sulfates, nitrates and acids. These can fall to earth in either dry or wet forms and, if wet, as fog, rain or snow.[70] They can also be inhaled and, because they are so fine, reach the deepest reaches of the lung.[71] Both wastes and their acids, also damage lakes,[72] streams[73] and forests,[74, 75] and sharply reduce visibility.[76]

Unlike the other contaminants, sulfates act as a cooling agent, although the net effect, according to the Intergovernmental Panel on Climate Change, is "quite uncertain," while the effect of nitrates is "less clear."[77]

Ozone. Perhaps the most pernicious of the transformed chemicals, however, is ozone, or smog. If there is a conceivable damage to be done to human health and the environment, ozone seems to do it.

Ozone is a largely invisible gas so toxic that it was once widely used to sterilize laboratory instruments.[78] Not unlike chlorine bleach, it destroys organic matter, including human tissue. At levels routinely encountered in most American cities, ozone burns through cell walls in lungs and airways. Tissues redden and swell.[79] Cellular fluid seeps into the lungs,[80-84] and over time scars and lesions form in the airways.[85]

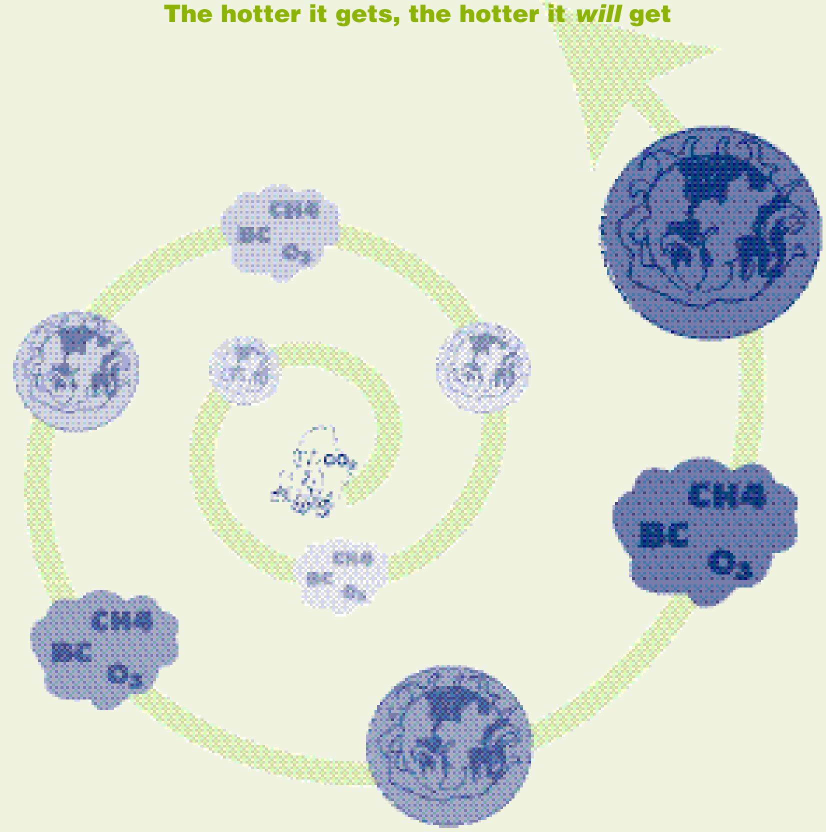
Children who play three or more sports in southern California ozone-polluted air develop asthma.[86] As ozone levels rise, hospital admissions and emergency department visits do the same.[87, 88] Not surprisingly, ozone exposure is linked to death.[89] Children at summer camp lose the ability to breathe normally as ozone levels rise and these losses continue for up to a week.[90]

Current levels of ozone, already hovering close to the toxicity threshold for many plants and animals, reduce yields, slow growth, lessen diameter and stem volume and slow photosynthesis in crops and trees.[91]

This is doubly troubling because the levels of ozone in rural areas, even over oceans, have increased sharply over the past century. Most scientists believe the natural level of ozone is 25 to 30 parts per billion, but levels routinely encountered in even remote areas of the United

HOW GLOBAL WARMING FEEDS ON ITSELF

The hotter it gets, the hotter it *will* get



States range from 40 to 80 ppb in winter and spring months.[92] When one team of researchers concluded that rural levels of ozone had doubled in a century, an observer remarked that the finding was "as remarkable as the observation of a hole in the stratospheric ozone layer over the Antarctic and potentially is just as consequential."[93]

The Hotter It Gets, the Hotter It Gets

What some scientists fear most is a "positive feedback," in which the Earth itself becomes a source of pollution—for example, methane currently in frozen tundra and cold peat bogs is released as higher temperatures trigger thawing, then the increased methane accelerates warming, thus producing more methane. Or, because formation of ozone increases in a linear fashion with rising temperatures, a continuous loop might start in which higher temperatures create more ozone, and more ozone leads to further warming. So it would go on and on, and the hotter it got, the hotter would get, causing not only higher temperatures, but higher levels of ozone, fine particles and other contaminants.

A few days after the United States dropped the atomic bombs that brought World War II to a close, Gen. Douglas MacArthur said:

> *We have had our last chance. If we do not devise some greater and more equitable system, Armageddon will be at our door.*
> Douglas MacArthur, Sept. 2, 1945

The same is true of the multiple threats posed to humanity today by massively poisoned air.

Reducing emissions of air pollutants will slow global warming, and minimizing releases of greenhouse gases will save lives that would otherwise be lost to pollution. A well inclined government genuinely committed to "sound" science, would recognize this and assemble a package of policy measures designed to save our lives and our future. Some governments are at least attempting to do this. Most are not.

Effects of Wastes in the Air

WASTE	DOES IT ALTER CLIMATE?	HOW IT DAMAGES HUMAN HEALTH	TIME FROM ELIMINATION TO CLIMATE BENEFIT
Carbon Monoxide	✔ *Yes!* Scavenges the hydroxyl radical, turns into CO_2	Kills those with congestive heart disease, starves fetuses of oxygen	Hours to months
Carbon Dioxide	✔ *Yes!*	Heat speeds ozone and fine particle formation; kills humans	30–95 years
Ozone	✔ *Yes!* Roughly as powerful as methane	Kills humans, causes asthma, increases illness	Weeks to months
Fine Particles ("Black Carbon")	✔ *Yes!*	Kills humans, increases hospitalization and illness	Weeks
Oxides of Nitrogen	✔ *Yes!* Creates ozone	Exacerbates asthma, increases heart attacks	Weeks
Volatile Organic Compounds	✔ *Yes!* Some are GHGs, all create ozone.	Some are toxic, all react to form ozone	Varies
Sulfur Dioxide	✔ *Yes!* Causes cooling	Linked to death, low birth weight and preterm birth.	N/A
Methane	✔ *Yes!* Second only to CO_2	Forms "background" ozone	10–12 years

Citations available at www.healthandcleanair.org

by David V. Bates, CM, MD, FRCP, FRCPC, FACP, FRSC

Trying to piece together the meaning of multiple epidemiological studies might be likened to trying to complete a very large jigsaw puzzle. There are certain constraints —for example one does not have the whole picture for guidance, and one cannot look at the available unused pieces, they are simply handed to you piece by piece. These thoughts came to mind when reviewing a recent paper in *Epidemiology*. Every so often I review a published paper that seems to me to be of major significance but has, as far as I know, been ignored in general media coverage. As one such paper surely constitutes a large piece of the jigsaw I am constructing, I thought I should highlight it here.

This study is of hospital emergency visits over an 8 year period from 31 hospitals in the Atlanta region. These comprised a total of more than 4 million visits. The statistical methodology included Poisson generalized estimating equations. In single pollutant models examining 3 day moving averages of pollutants (with lags of 0, 1 and 2 days) the standard deviation increase in the pollutants (see below) were associated with a 1-3% increase in respiratory visits. All the pollutants except SO_2 were involved (O_3, NO_2, CO, and PM10), and in the case of COPD visits, SD increases in NO_2 and CO were associated with a 2-3% increase in emergency visits. A 2 microgram/m3 increase in PM2.5 organic carbon was associated with a 3% increase in pneumonia visits. It was noted that positive associations persisted beyond 3 days for several of the outcomes, and over a week for asthma. The SD values to which these associations applied were: 24 hour PM10 = 10 micrograms/m3: 8 hour O_3 = 25 ppb: 1 hour NO2 = 20 ppb; 1 hour CO = 1 ppm: 1 hour SO2 = 20 ppb.

This uniquely large bank of data constitutes a major section of the jigsaw we have to construct because it shows that if your sample is large enough, you capture the effect of ozone in the summer, and of the combustion emission pollutants as a group in the winter as well as the summer. And not surprisingly, it shows that all the pollutants are individually important.

This remarkable study was, as far as I am aware, generally ignored by the national media; it provides striking evidence of the reality of the many individual studies that have been published. The modern city environment, from the point of view of aggravation of respiratory disease, is not sustainable; and this study gives us strong confirmation that this position is correct. It is difficult to imagine a study which, by virtue of its power, gives us such a strong signal as does this one.

A recent Research Report of the Health Effects Institute complements the Atlanta analyses. In it, 36 elderly subjects in Amsterdam and 40 in Helsinki were studied. All were non-smokers between 50 and 84 years old, and all had moderately advanced heart disease. Personal, indoor and ambient PM2.5 levels were studied, and in both cities, personal and indoor exposures were higher than outdoor concentrations, but highly correlated with them. Analyses were done both on those exposed to environmental tobacco smoke and those not. The research group found a correlation coefficient of about 0.8 between the personal and ambient levels of exposure, which effectively disposes of the argument that the epidemiological data cannot be believed because the ambient data will not accurately reflect the personal exposures. At least in these groups of high risk patients in two different cities, this was not the case.

I have always been interested in the history of air pollution and hence I noted a recent letter by Robert Maynard to the *Journal of Occupational and Environmental Medicine*. Maynard writes that Thomas Parr died at the age of 152 after having been brought to London. At his autopsy, William Harvey commented on the possible contribution of air pollution to his death: "Especially did he suffer harm from the change of air, for all his life he had enjoyed absolutely clean, rarefied, coolish, and circulating air, and therefore his diaphragm and lungs could be inflated and deflated and refreshed more freely. But life in London in particular lacks this advantage—the more so because it is full of the filth of men, animals, sewers, and other forms of squalor, in addition to which there is the not inconsiderable grime from the smoke of sulphurous coal constantly used as a fuel for fires. The air in London is therefore always heavy, and in autumn particularly so, especially to a man coming from the sunny and healthy districts of Shropshire, and it could not but be particularly harmful to one who was now an enfeebled old man." This comment is dated from November 1635.

Worth Noting

Almost any competent bench scientist who studies mercury knows of its perils: Dartmouth College scientist Karen Wetterhahn died in 1997 after a single drop of dimethylmercury apparently passed through her protective gloves.

Another form of the poison, methylmercury, ravaged thousands of Japanese in the 1950s and 1960s after they ate fish contaminated by industrial wastes. In Iraq, during the winter of 1972-73, wheat seeds earmarked for next year's crops were treated with methylmercury to prevent rotting. The seeds were mistakenly distributed free in rural areas and eaten. Of roughly 50,000 people exposed, 459 died, and 6,530 were hospitalized.

Throughout the world, the largest single human source of mercury is the burning of coal, which in the U.S. accounts for four of every ten pounds emitted. After falling to earth, mercury moves up the food chain, concentrating in the flesh of tuna, sharks and other large predators.

Mercury is dangerous at even vanishingly small levels. For example, a study of the residents of the Faeroe Islands found that children whose mothers ate fish and, especially, whale meat, while pregnant had reduced cognitive abilities. Another study found evidence of slower growth in children who were breast-fed with milk contaminated by mercury.

Mercury's threat is serious enough that the U.S. government recommends that women of childbearing age who are pregnant, as well as young children, eliminate swordfish, tile fish and other top-of-the-chain fish from their diets. Yet not everybody shares this concern: Wisconsin Electric, for example, a coal-burning electricity company, reassures consumers that "Most Americans, however, eat very little fish."

This Newsletter deals with the non-difference between "air pollutants" and "greenhouse gases." Mercury is another case in point of this non-divisibility: after pouring from smokestacks, mercury is converted in soils and waters into the methylated form that can concentrate in flesh, and this methylation rate is temperature dependent. Thus, higher water temperatures will mean higher levels of methyl mercury. Indeed, the temperature effect is so pronounced that a very recent study concluded that Faeroe Islanders should cut their consumption of whale meat, a traditional food source, by half to offset the mercury effect of global warming.

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