HEALTH & CLEAN AIR
newsletter
Fall-Winter 2002

do you have *YOUR* copy?

Co-editor David Bates and a distinguished team of authors have completed their *Citizens Guide to Air Pollution*, which can be yours for a few dollars ($20 USD, $25 Cdn.). For subscribers to this *Newsletter*, Dr. Bates will gladly personally autograph a copy. Order your copy — and request an autograph — through the David Suzuki Foundation Website at www.davidsuzuki.org or by emailing orders@davidsuzuki.org. It is also available on amazon.com.

Smog:
Nature's Most Powerful Purifying Agent

Los Angeles uses ozone, the principal ingredient of smog, to disinfect its drinking water, as do many other cities throughout the world. It's terrific: bacteria, dirt and other contaminants are chemically oxidized in much the way fire consumes paper or chlorine-based bleach zaps that dingy "ring around the collar." Not surprisingly, breathing the atmospheric equivalent of bleach isn't so good for the lungs, however, which is why ozone has been regulated since the enactment of the landmark Clean Air Act Amendments in 1970.

Recently, however, research advances have yielded new and profoundly unsettling evidence, confirming what a few researchers have long believed: namely, that ozone is a vastly more dangerous pollutant than most have previously believed. The studies are of different sorts: one examines rhesus monkeys exposed to ozone; another compares the respiratory health, school absences and illnesses of children living in some the nation's most polluted regions to others in less polluted areas; while a third compares the ability to breathe of college students raised in Los Angeles with others raised in the San Francisco Bay area.

These and other recent studies suggest that over time, ozone permanently and irrevocably alters the lungs themselves. In effect, merely because they are breathing, children develop lungs that are functionally smaller and stiffer than they should be, with lesions and scars not unlike those found in tobacco smokers. They bear many of the hallmarks of asthma, handicaps that they may well carry for their entire lives. These are sensible results precisely because ozone is such a powerful oxidant that it can sterilize laboratory instruments and disinfect water. Indeed, ozone is so potent that researchers conducting studies of its effects in glass enclosed chambers have historically been unwilling to enroll even healthy women in tests for fear of possible injury to an unborn child. This *Newsletter* reviews these and other studies.

Ozone, the Eager Destroyer

Ozone is three atoms linked together so weakly that the molecule easily disintegrates into a two-atom oxygen molecule and a single oxygen atom that instantly reacts with organic matter, whether it's a bacterium in water or the cell wall of a lung. It has been known for a decade or more that at levels routinely encountered in most American cities, ozone burns through cell walls in lungs and airways. Tissues redden and swell. Cellular fluid seeps into the lungs and over time their elasticity may change.

Neutrophils, specialized white blood cells that are the body's first line of defense against bacteria, viruses, molds and other threats, rush to the lung's aid, but they too are stunned by the ozone. Susceptibility to bacterial infections increases, possibly because ciliated cells that normally expel foreign particles and organisms have been killed and replaced by thicker, stiffer, non-ciliated cells. Scars and lesions form in the airways.

At ozone levels that prevail through much of the year in California and most other cities during warmer weather, healthy, non-smoking young men who exercise can't breathe normally. Breathing becomes rapid, shallow and painful.

As ozone levels rise, hospital admissions and emergency department visits do the same. When ozone levels increase 20 parts per billion — a common daily variation — school absences due to general illness increase 62.9 percent, while those for respiratory sickness jump 82.9 per cent. Children at summer camp lose the ability to breathe normally as ozone levels rise, even when the air is clean by reference to the federal standard, and these losses continue for up to a week.

These and the litany of other ills caused by ozone are why it was among the first air pollutants to be regulated after adoption of the U.S. Clean Air Act in 1970. Today, more than 30 years later, efforts to rid our cities of this pollutant must be deemed, at best, an incomplete success.

The scientific community now has strong reason to believe that, unlike stratospheric (i.e., high altitude) ozone concentrations, which are declining, concentrations of tropospheric (i.e. near-ground) ozone are generally increasing over large regions of the United States.

National Research Council, 1991

The Record of Incomplete Success

The American Lung Association analyzes government pollution data each year to determine how many Americans are breathing air that damages health. In 2001, roughly 141 million people lived in the over 400 counties that violate air quality standards. Although ozone levels do vary significantly from year to year depending on emissions and temperature (the formation of ozone is linked directly to temperature, so when it rises, so does smog), the 2001 levels represented an increase in the population at risk of 15 percent over 2000.

Ozone is so prevalent that even seemingly unpolluted rural or wilderness areas are clouded. In the Virginia mountains of Shenandoah National Park, for example, ozone concentrations are among the highest in the country, and frequently exceed the law's health based standards. Much the same is true in Acadia National Park, whose rocky cliffs hug the frigid Atlantic waters off Maine. In the Great Smoky Mountains National Park in Tennessee and North Carolina ozone levels rival those of Los Angeles, while in California's Sequoia and Kings Canyon National Parks, ozone concentrations exceeded human-health standards on 61 summer days in 2001. During summer, ozone levels in these parks exceed the California Health Standard an average of one out of every three days at low-elevation sites and one out of every five days at mid-elevation sites.

Indeed, although ozone concentrations tend to be highest in and downwind of cities, virtually the entire United States — excepting only portions of the Pacific Northwest — is blanketed by the pollutant at levels that have been demonstrated to reduce lung function. In tests, for example, of 58 farms workers at Abbottsford and Matsqui, Canada, about 42 miles (70 kilometers) southeast of Vancouver, researchers found that as ozone concentration rose, the ability to breathe normally fell, even though aver-

Although ozone concentrations tend to be highest in and downwind of cities, virtually the entire United States...is blanketed by the pollutant at levels that have been demonstrated to reduce lung function.

HEALTH & CLEAN AIR newsletter

The *Health and Clean Air Newsletter* is co-edited by Curtis Moore and David Bates, M.D. Reviewers include Drs. John Balmes, Bart Croes, Shankar Prasad and George Thurston. Correspondence may be addressed to HCAN, 1100 Eleventh Street, Suite 311, Sacramento, California 95814. Issues, abstracts and citations may be found at www.healthandcleanair.org

age concentrations were only one-third of the U.S. standard. *Ozone levels in this study were, in other words, at levels that prevail virtually constantly during the warm weather periods throughout much of North America, Europe and Asia.* Even more alarming, these deficits were still present the following morning.

The Steadily Rising Tide

Finding adverse health effects at such low levels is troubling in part because so-called "background" concentrations of ozone — those that prevail most of the time in most of the nation — are rising. According to the U.S. National Oceanic and Atmospheric Administration, "Over the last one hundred years the ozone concentrations near the ground in the northern middle latitudes have more than doubled. Several sources support a lower- tropospheric ozone increase of greater than 1 per cent per year since the end of the nineteenth century."

It now seems certain that over the long term ozone does, in fact, actually change the size, shape and function of lungs.

The damage inflicted by ozone begins with the first breath, when it stimulates the C-fiber nerve endings in the airways, triggering pain and rapid breathing. The objective changes in breathing — shortness of breath, with shorter and more frequent respiration — has been thought to be a result of the pain. But when pain is quieted with an inhaled anesthetic, the abnormal breathing continues, indicating that the two responses — pain on the one hand and abnormal breathing on the other — are independent of one another.

The ozone travels deeper into the lungs, inflaming tissue. Neutrophils mobilize to repel the threat, entering not only the airways, but the lung tissue itself. The number of these white blood cells in lung tissue in subjects exposed to ozone is more than six times that in people breathing clean air. What exactly happens next and why is incompletely understood, but clearly ozone clearly triggers illness, especially in asthmatics.

For example, when scientists at the University of Southern California compared school absences for respiratory illness to levels of air pollution, they found a remarkable fit: as ozone levels rose, so did missed school due to sore throats, cough, asthma attacks and other respiratory illnesses. For an increase in concentration of 20 parts per billion, a common day-to-day variation in highly-polluted Southern California, absenteeism for respiratory causes jumped 83 percent. That same 20 ppb increase was associated with sharp jumps in specific ailments. Upper respiratory illnesses rose 45 percent, while lower respiratory illnesses with wet cough jumped 174 percent. Such ailments could well be transitory, temporary discomfort that abates when ozone levels fall. But some researchers have wondered whether the opposite might be true: namely, that ozone impacts are long lasting, or even permanent. Some studies have suggested that this might be the case. For example, when eight healthy adult volunteers were exposed on four consecutive days to alternating doses of smog and clean air, breathing tests indicated that their small airways had been constricted by ozone. This is a change characteristic of asthma.

In addition, when they exercised after ozone exposure, the volunteers' breathing was unnaturally rapid, which is another symptom of lung illness. Still, this evidence was circumstantial, leaving the researchers to conclude that "The possible relationship between these persistent changes in small airway function, measured in days, and the likelihood of cumulative injury in the same region if exposure is long term, is unknown."

Recent studies seem to have answered this question, for it now seems certain that over the long term ozone does, in fact, actually change the size, shape and function of lungs. There are three key studies that point to this conclusion:

Rhesus Monkeys. Rats and many other laboratory animals are born with lungs that are fully developed are nearly so. However, humans and other primates, such as rhesus monkeys, are born with respiratory systems that still are maturing. At the University of California at Davis, rhesus monkeys of various ages were exposed to air contaminated with ozone for five days, followed by nine days of normal air. This cycle was repeated every two weeks for five months, mimicking the effect of exposure to occasional ozone smog.

Young monkeys exhibited all the symptoms of asthma in humans: structural and cellular changes like those seen in human asthmatics; airway hyperresponsiveness, in which airways close down more dramatically; and, loss of a key protective chemical, glutathione, from lung fluids and cells, to name but a few. Then, there were other remarkable findings: division of the airways, which ought to branch 13 times, halted at 9; and, changes in the lung's immunology.

If the changes observed in the young monkeys occurred in humans, and they were permanent, they should be manifested in breathing tests. They are.

Freshman from Polluted Areas Compared to those from Cleaner Cities. Unlike monkeys, humans cannot be sacrificed so their respiratory systems can be examined. However, if the structural changes

observed in juvenile rhesus monkeys also occurred in humans, this should be evidenced by differences in certain breathing tests, especially FEV_{25-75}. (Exhaling as hard and fast as possible measures forced expiratory volume, or FEV. The amount of air that flows between 25 and 75 percent of FEV, or FEV_{25-75}, reflects whether small airways — the part of the lung just before the exchange of oxygen and carbon dioxide occurs — are obstructed, which is another of asthma's symptoms.)

Researchers at the University of California at Berkeley examined 130 freshmen, all of whom were lifelong residents of either the Los Angeles Basin, where smog is the worst in the nation, or the San Francisco Bay area, which is relatively less polluted. Using detailed residential histories, pollution monitoring data, the students' activity patterns, the lifetime exposures to ozone were calculated. After the students' breathing was tested, researchers found a "consistent" association between ozone exposure and declines in FEV_{25-75}. A study of 520 Yale freshmen reached similar conclusions.

Children Living in Southern California. Finally, if the direct evidence of the monkey studies and the indirect evidence of the examination of college freshman are correct, children who live in polluted areas should suffer from lung diseases at a higher rate than children raised in less polluted neighborhoods. They do.

In Southern California, researchers have mounted one of the most ambitious air pollution research programs in history, a ten-year, 12-community study of the impact of air pollution on lung health and growth. Starting in 1991, researchers began tracking over 5,500 school age children, comparing their activities, illnesses, places of residence and a wide range of other variables. This work has yielded a range of striking and worrisome results: ozone increases school absences; fine particulate matter of the sort emitted by diesels increases bronchitis in asthmatic children; and, fine particles, oxides of nitrogen and acids decrease lung function growth. But none of the results is so profoundly alarming as the apparent association between exposure to ozone and the development of asthma.

Sweden has enjoyed remarkable success reducing both oxides of nitrogen and fuel-bound sulfur with revenue-neutral fees in which relatively high polluters pay into a fund and relatively low polluters receive money.

Researchers found that children who play three or more sports — which would increase their dose of air pollution — and who live in neighborhoods with higher ozone levels are three times more likely to develop asthma as those who play no sports or live in lower ozone communities. However it should be noted that because this was a prospective study, the actual numbers were small.

Taken together, these studies and those that have gone before, constitute a compelling, consistent and coherent body of evidence suggesting that long term exposure to ozone results in profound and permanent damage to the body's respiratory system, beginning at the earliest ages.

Policy Implications

Virtually all nations now regulate air pollution on a substance-by-substance basis, establishing standards one year for, say, carbon monoxide and the next for, perhaps, oxides of nitrogen. This may be a sensible approach for purposes of isolating and identifying the health effects of a specific pollutant, but it fails to take account of the reality that most vehicles, power plants, refineries, and factories emit several pollutants, not just one. The victims of single-pollutant regulation (aside from the human victims, of course) are the many policies and measures that can simultaneously eliminate all of the pollutants from a smokestack or tailpipe — indeed, some can make tailpipe and smokestacks a thing of the past, because they produce no air pollution whatsoever.

Fuel cells, for example, (which are devices that generate electricity through a chemical reaction rather burning fuel in an engine or furnace) produce only water vapor and kilowatts. They can be used in vehicles ranging from locomotives to cars. Likewise, wind turbines produce zero air pollution.

Such technologies have difficulty entering the marketplace, however, because gasoline, coal, natural gas and other fuels are cheaper — well, cheaper if the only measure of their cost is money. What the recent research on ozone demonstrates is that these fuels are being subsidized by human health, even at very low levels. Somewhere, there is a child paying with his or her health for the cheaper kilowatts being fed into an aircraft assembly plant, for example.

The information reviewed in this *Newsletter* makes it clear that these costs may include permanent, irrevocable damage to the human respiratory system. Were this Newsletter focusing on particulate matter, it would be clear that the damage includes death.

Perhaps it is time to re-evaluate and supplement the single pollutant approach, examining the feasibility of a more dynamic, comprehensive system. Sweden, for example, has enjoyed remarkable success reducing both oxides of nitrogen and fuel-bound sulfur with revenue-neutral fees in which relatively high

asthmatics — at special and higher risk

Whether or not ozone causes asthma, it is clear beyond dispute that those who suffer from the disease are at higher risk from ozone. The recent study that most clearly and unequivocally demonstrates this was the natural experiment in 1996, when the summer Olympics were held in Atlanta.

Anxious to lessen the typical summer levels of smog, some of the nation's worst, Atlanta officials asked drivers to park their cars. They also closed the downtown area to car traffic, added buses and trains, and aggressively promoted flexible work schedules, car-pooling, and telecommuting. It all worked, providing an answer to those who always claim that the public will not inconvenience itself to reduce air pollution.

Weekday 1-hour morning peak traffic counts in Atlanta decreased 22.5 percent overall during the Olympic Games, while public transit ridership rose 217 percent. Peak ozone concentrations fell by 13 percent, and so did visits to hospitals, doctors and emergency rooms for asthma complaints. Among children aged 1 through 16 in the Medicaid claims files, the number of asthma emergency care visits declined 41.6 percent. Among HMO enrollees, the decrease was 44.1 percent, while citywide hospitalizations for asthma were off 19.1 percent and visits to the two pediatric emergency departments dropped 11.1 percent. (These improvements in public health occurred even though the levels of ozone and other pollutants were below the health-based standards established by the Environmental Protection Agency for criteria pollutants.)

A 15-year study in Toronto that compared daily hospital records with pollution levels found that when ozone rose, so did emergency or urgent care admissions for croup, pneumonia, asthma and acute bronchitis/bronchiolitis. A similar study in Brisbane of 41,127 hospital admissions including 13,246 admissions for asthma between 1987 and 1994 found that "Ozone was consistently associated with admissions for asthma and respiratory disease — with little evidence of a threshold." The Brisbane study was important because in that city there are no associated aerosol sulphates — these are highly correlated with ozone in the northeastern part of North America — hence the study provides direct evidence of the importance of ozone. Researchers in Houston, Texas found a similar association between increased ozone and emergency room visits for asthma.

For adults with severe asthma, the risks are even greater. In Barcelona, researchers followed 1,078 severe asthmatics who visited a local emergency room. When ozone levels were higher, so was their risk of dying. In Paris, a panel of 60 severe adult asthmatics were followed over a 13-month period. When ozone concentrations increased, asthma attacks rose, each of which was verified by an attending physician. Similarly, the need for for medication by asthmatic children attending summer camp was directly related to the ozone levels. ■

polluters pay into a fund and relatively low polluters receive money. Germany has successfully applied the "precautionary principle" — when in doubt, err on the side of avoiding damage to health and the environment. Japan places considerable power in the hands of the neighbors of industrial facilities.

Another victim of the single-pollutant approach is research. As evidence of the increased toxicity of one pollutant emerges, funding for work on others is reduced, almost as if a tacit decision has been made that because, say, particulate matter is more dangerous, ozone must be less so. In fact, all of these pollutants are, by definition, grave threats to human health. Perhaps here, too, a new approach is required. Most certainly, neglect of the ultimate source of decision information, research, is not the answer. ■

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

Nature's Great Cleanser

In the late Victorian era in Britain, it was accepted that ozone was "healthy." It was believed that it was stronger at the seaside (due, I suspect to the similarity of its smell to that of seaweed), and families went there for a healthy environment (not too bad an idea since the cities were heavily polluted).

Schonbein discovered the formula for ozone in 1833, but he knew that it was a highly irritant gas; so where did the idea that it was healthy come from? Dr. Bill Linn from Rancho Los Amigos discovered the answer to this question when he unearthed a piece of doggerel verse written by W.S.Gilbert (of Gilbert and Sullivan fame) and published in the "Bab" Ballads. A letter had been written to *The London Times* calling ozone "Nature's Great Cleanser" and extolling its bactericidal capabilities, and Gilbert had clearly seen this; hence the doggerel verse.

Today, of course, we know that the effects of "Nature's Great Cleanser" are ill health, not good health, even at remarkably low levels. This, together with additional information we now have on the London Smog Disaster of December 1952, prompts some thoughts on the general topic of air pollution and its control. It is significant that the Government of Britain suppressed (successfully) the full measure of the excess mortality associated with that event. I note that Harold MacMillan, the Minister who replied for the government on that episode, does not mention it in his autobiography (he had presumably succeeded in eliminating it from his consciousness). Had the episode involved an attack by the IRA at the time resulting in 12,000 deaths, it could hardly have been forgotten or overlooked.

With the clear definition of the effect of low concentrations of ozone (less than 100 ppb) on inducing falls in lung function and airway inflammation if it is breathed during exercise; and the generality of exceedances of current standards over most of North America; and the large numbers of studies showing that elevations of ozone in the summer are associated with increased hospital admissions and emergency visits by people with asthma, it is not surprising that ozone has become a pollutant of concern.

Regulatory authorities, and particularly the US EPA, have shown an ambivalent attitude towards the problem of tropospheric ozone. To my knowledge, variable messages have come out of EPA headquarters over the years — for a period about every three years the message was that no further attention should be paid to ozone. I was personally aware that a high level effort was made to derail the National Academy of Sciences study that resulted in the publication of the report *Rethinking the Ozone Problem*. This was one of the few valuable and critical studies of the problems of reducing ambient ozone levels, and of measuring whether any effective reduction had occurred.

Maybe this pollutant simply gets shuffled into the "too difficult" basket, and that accounts for the ambivalence. It may also be that the need to be shown to be doing something effective subverts the regulatory attitude, since it is difficult to be sure what is being achieved in relation to ozone. Often lower values in static monitors do not reflect the higher values that are occurring further downwind where no monitors are located.

Many years ago, I had the experience in Australia of hearing a senior bureaucrat remark that in New South Wales, although emissions of NO2 had gone up, levels of ozone had gone down. My fellow invited keynote speaker, Dr. Art Winer, from Los Angeles, put his hand up and pointed out that very likely, further downwind the levels of ozone had risen; whereat a member of the public went to a microphone and said: "They put a monitor in Parrammatta, but it showed such high values that they took it away." ■

Worth Noting

Woodsman, Spare that Tree — and Your Child

On a cold winter's night, there's little as peaceful and relaxing as the crackling blaze in a fireplace. Plus, for those strapped for cash, it's an inexpensive way to provide heat. Unfortunately, it might not be so good for your child's health.

When researchers at Michigan State University followed 62 children between the ages of one and seven randomly selected from those attending a clinical center, they found that severe respiratory symptoms were commoner in children from homes using wood for heating, compared to children from homes using fuel oil or gas furnaces. In an earlier study, the same researchers recounted the experience of a child with recurrent episodes of pneumonia whose respiratory symptoms quickly disappeared after admission to the hospital.

Needed: Ingenuity and Dedication

Indeed, study after study continues to affirm findings that fine particles, whether emitted by the burning of wood or other biomass or from diesel and gasoline engines, coal fired power plants, or other sources, cause not only serious illness but death. New data is appearing at a rate that makes it hard to keep up with the information. Some of the studies not only add to the body of evidence, but highlight the need bring engineering and other ingenuity to bear. One researcher, for example, undertook a detailed analysis of indoor air pollution exposures due to open stove emissions, together with a comprehensive survey of the literature. Estimates of global mortality due to indoor air pollution from solid fuels in the year 2000 place total mortality at between 1.5 and 2.0 million deaths. This is 4 to 5 percent of total mortality worldwide, and one million of the deaths are believed to be of children.

Like virtually all deaths due to air pollution, these could be avoided if the means could be found to eliminate combustion particles. Yet for engineers and the firms that hire them, there are much higher — and more profitable — priorities.

Exposure to biomass combustion particles is by no means limited to developing nations, as a study from Sweden underscores. Like many areas, wood is an important source of heat in Sweden: roughly one-third of the homes are completely or partially heated by burning firewood, and in 1998, there were 38,000 fireplaces, wood stoves and the like in Stockholm. Fireplaces and stoves emit not only large quantities of fine particulate matter, but also a group of chemicals called polyaromatic hydrocarbons (PAHs). A recent analysis there found that the toxic compounds fluorine, phenanthrene, anthracene, fluoranthene and pyrene together contributed 70 percent of the total mass of polycyclic aromatic hydrocarbons (PAH) from wood combustion.

Researchers found that severe respiratory symptoms were commoner in children from homes using wood for heating, compared to children from homes using fuel oil or gas furnaces.

A study from Christchurch, New Zealand leaves little doubt that wood smoke is dangerous. A city of about 330,000, Christchurch has an estimated 47,000 wood burners and open fires, almost all wood, though some coal is used. There is no heavy industry and only local traffic, but severe winter inversions can trap smoke and soot from wood burning. As levels rose slightly — about 5 percent — acute hospital admissions for respiratory disease increased by 3.7 percent and for pneumonia by 5.3 percent.33 Admissions for cardiovascular disease were also increased, but to a lesser extent.

Environmentally approved wood stoves in Sweden reduce emissions of benzpyrene by about 88 percent and total PAH by about 98 percent. If these technologies were adopted widely, and could be extended to suppress indoor emissions from cooking and the like, the world's ill health burden could be lessened greatly.

(continued on page 8)

WORTH NOTING

(continued from page 7)

Whose Cost, Whose Benefit

Almost invariably, polluters and their defenders will insist that a cost-benefit analysis be conducted before new emissions controls are adopted that might threaten the bottom line of corporations. One problem with this approach (quite aside from the necessity of assigning a dollar value to the life and health of people who breathe the air) is that sometimes the health benefits can't be predicted. Eliminating lead from gasoline is a case in point.

The principal reason that lead was eliminated from gasoline starting in the 1970s was to protect the catalytic converters used on cars to destroy the unburnt gasoline and other pollutants spewing from the tailpipes. Because lead clogs the platinum, palladium and other precious metals used in the catalysts, the cars makers sought the lead ban to protect them from the multi-billion dollar costs of having to replace poisoned converters. Later, researchers found that blood levels of lead, which destroys intelligence in children, dropped in lock step as the metal was removed from gasoline. This provided an effective answer to those industrial apologists who had always claimed that the lead in gasoline did not influence the level of lead in the blood. Now there is proof that eliminating lead not only saved money for the car makers, but for all Americans. When researchers calculated the economic benefit of improvements in worker productivity due to the intelligence increase resulting from the lead ban, they found that it ranges from $110 billion to $319 billion per year. Tragically, the manufacturer of the lead additive that fought the U.S. ban, the Ethyl Corporation of Richmond, Virginia, still sells the poisonous compound in developing nations, accounting for roughly one of every six gallons of gasoline sold globally. ■

1100 Eleventh Street, Suite 311
Sacramento, CA 95814

HEALTH & CLEAN AIR newsletter