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#440 - The Holy Grail Of Scientific Certainty
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Air pollution from the combustion of fossil fuels (oil, coal, and natural gas) in cars, trucks, and power plants, is killing roughly 60,000 Americans each year, according to researchers at Harvard University's School of Public Health.[1] (See REHW #373.) This represents about 3% of all U.S. deaths each year. Every combustion source is contributing to the death toll; none is benign, including incinerators; soil burners; flares and after-burners; industrial and residential heaters and boilers; cars; buses; trucks; and power plants. Diesel vehicles and oil-and coal-burning power plants seem to be the worst offenders.

The culprit in every case is the fine particles --invisible soot -- created by combustion. Fine particles are not captured efficiently by modern pollution-control equipment. Furthermore, they are not visible except as a general haze. They are far too small to be seen.

According to more than a dozen studies, there seems to be no threshold, no level of fine-particle pollution below which no deaths occur. Even air pollution levels that are well within legal limits are killing people, especially older people, and people with chronic heart and lung ailments, the Harvard researchers have found.

Furthermore, studies indicate that fine-particle pollution is causing or exacerbating a wide range of human health problems, including: initiating, and worsening, asthma, especially in children; increasing hospital admissions for bronchitis, asthma, and other respiratory diseases; increasing emergency room visits for respiratory diseases; reducing lung function (though modestly) in healthy people as well as (more seriously) in those with chronic diseases; increasing upper respiratory symptoms (runny or stuffy nose; sinusitis; sore throat; wet cough; head colds; hay fever; and burning or red eyes); and increasing lower respiratory symptoms (wheezing; dry cough; phlegm; shortness of breath; and chest discomfort or pain); and heart disease.[1]

Since 1987, U.S. Environmental Protection Agency (EPA) has been measuring fine-particle air pollution, calling it PM10, which means "particulate matter 10 micrometers or less in diameter." A micrometer is a millionth of a meter, and a meter is about a yard. The dot above the letter i in a typical newspaper measures about 400 micrometers in diameter.

EPA measures PM10 pollution by weight --the total weight of all particles with a diameter of 10 micrometers or less in each cubic meter of air. The legal limit is 50 micrograms of PM10 particles in each cubic meter of air, as a year-round average. (A gram is 1/28th of an ounce, and a microgram is a millionth of a gram.) Many U.S., Canadian, and European cities from time to time will have as much as 100 to 200 micrograms of PM10 particles in each cubic meter of air.

The size of the particles is what's most important from a public health viewpoint. Particles larger than 10 micrometers generally get caught in your nose and throat, never entering the lungs. Particles smaller than 10 micrometers can get into the large upper branches just below your throat where they are caught and removed (by coughing and spitting or by swallowing). Particles smaller than 5 micrometers can get into your bronchial tubes, at the top of the lungs; particles smaller than 2.5 micrometers in diameter can get down into the deepest (alveolar) portions of your lungs where gas exchange occurs between the air and your blood stream, oxygen moving in and carbon dioxide moving out.[1,2] These are the really dangerous particles because the deepest (alveolar) portions of the lung have no efficient mechanisms for removing them. If these particles are soluble in water, they pass directly into the blood stream within minutes. If they are not soluble in water, they are retained in the deep lung for long periods (months or years).[3]

About 60% of PM10 particles (by weight) have a diameter of 2.5 micrometers or less.[1] These are the particles that can enter the human lung directly. (They also enter homes; indoor air and outdoor air typically contain the same quantities of fine particles, so buildings provide no refuge from these invisible killers.) Let's go back to the dot over the letter i. If particles are 10 micrometers in diameter, then 1600 particles can fit on the dot. If the particle diameter is 2.5 micrometers, then 25,600 particles can fit on the dot. When the diameter drops to 0.3 micrometers, then 1.8 million particles can fit on the dot, and when the diameter is reduced to 0.001 micrometers, or one nanometer, then 160 billion (1.6E11) particles can fit on the dot over the letter i.

In a modern U.S. city, on many days, the air will contain 100 billion (1E11) one-nanometer-diameter particles in each cubic meter of air, all of them invisible.[2] By weight, these 100 billion particles will only amount to 0.00005 micrograms (one ten-thousandth of 1 percent of the 50-microgram legal limit), yet they may be responsible for much of the health damage created by fine-particle pollution. For this reason, in 1979, the National Research Council said that measuring particles by weight, without regard to particle size, has "little utility for judging effects."[4] Particle size is everything when it comes to air pollution and health.

The study of fine particles and their effects on human health has been under way in earnest since 1975. During the past 20 years, studies have been able to rule out sulphur dioxide and ozone pollution as the cause of the observed deaths.[5] This year a new study of 552,138 adult Americans in 151 metropolitan areas confirmed once again that there is a clear relationship between fine-particle air pollution and human deaths, and it ruled out smoking as a cause of the observed deaths.[6] This study is particularly important because it didn't simply match death certificates with pollution levels; it actually examined the characteristics (race, gender, weight and height) and lifestyle habits of all 552,138 people. Thus the study was able to rule out tobacco smoking (cigarettes, pipe and cigar); exposure to passive tobacco smoke; occupational exposure to fine particles; body mass index (relating a person's weight and height); and alcohol use. The new study also controlled for changes in outdoor temperature. The study found that fine-particle pollution was related to a 15% to 17% difference in death rates between the least polluted cities and the most-polluted cities.

Up until this year, researchers have shown that fine particles cause death and disease, but the mechanism by which this occurs has remained a mystery. A new hypothesis, published in January in the British medical journal LANCET, suggests that the particles retained in the deep lung cause inflammation which, in turn, releases natural chemicals into the bloodstream causing coagulation of the blood.[2] This hypothesis is proposed as the biological mechanism by which fine particles cause respiratory and heart-related diseases and death.

One might ask why steps weren't taken long ago to prevent the disease and death associated with fine-particle pollution. After all, the National Academy of Sciences said as early as 1979 (16 years ago) that "...alveolar retention of relatively insoluble particles is recognized to be important to the pathogenesis of chronic lung disease..."[7] In other words, the Academy was convinced 16 years ago that fine particles retained in the deep lung cause long-term lung disease. The Academy said at that time, "In summary, particulate atmospheric pollutants may be involved in chronic lung disease pathogenesis as causal factors in chronic bronchitis, as predisposing factors to acute bacterial and viral bronchitis, especially in children and cigarette smokers, and as aggravating factors for acute bronchial asthma and the terminal stages of oxygen deficiency (hypoxia) associated with chronic bronchitis and/or emphysema and its characteristic form of heart failure (cor pulmonale)."[8]

If the Harvard researchers are correct in their estimate, that 60,000 Americans die each year from fine-particle pollution, and tens of thousands more are made sick (especially children), then we can calculate that, since 1979, nearly a million Americans (960,000) have been killed by fine particle pollution, and millions more have

been made sick.

Why can't we act to prevent this important problem? Because U.S. regulatory agencies--and the courts--have lost their way, searching for the holy grail of scientific certainty. Regulators and judges now insist that science has to "prove harm" before regulatory control can begin. Philosophers of science know that science cannot "prove" anything.[9] It often takes science decades --sometimes centuries --to reach a clear majority opinion and there will always be uncertainties, giving rise to nagging doubts, which can only be laid to rest by further study. In the meantime, the science of 1979 was sufficient to tell us that people are dying and children are getting sick because of fine particles. The precise mechanism of harm is, even today, not fully understood, but the harm itself has been clear beyond any reasonable doubt for many years. Common sense says that the National Academy's conclusions back in 1979 should have been sufficient for regulators to clamp down in earnest.

The long history of fine-particle research raises a series of difficult questions: When did our society first turn away from the common sense, weight-of-the-evidence, preventive approach which, theoretically at least, guides public health decisions? What role did corporate lawyers and scientists play in convincing scientifically-illiterate judges and politicians that scientific certainty was required before society could take prudent steps to protect public health and safety? What steps can concerned citizens take NOW to move our society back toward a prevention-based approach to the control of dangerous materials and technologies?

--Peter Montague

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[1] D.W. Dockery and C.A. Pope III, "Acute Respiratory Effects of Particulate Air Pollution," ANNUAL REVIEW OF PUBLIC HEALTH, Vol. 15 (1994), pgs. 107-132.

[2] Anthony Seaton and others, "Particulate air pollution and acute health effects," THE LANCET Vol. 345 (January 21, 1995), pgs. 176-178. Seaton says air containing 100 to 200 micrograms of pollutants in each cubic meter of air will contain up to 100,000 nanometer-sized particles in each milliliter of air. There are one million milliliters in a cubic meter. We calculated the total weight of these particles assuming they have the same density as water (one gram per milliliter). For comments on the hypothesis of Seaton, see Raymond Agius, "Airborne pollutants and acute health effects," THE LANCET Vol. 345 (March 25, 1995), pg. 799; and Gunter Oberdorster, "Airborne pollutants and acute health effects," THE LANCET Vol. 345 (March 25, 1995), pgs. 799-800; and Dick van Steenis, "Airborne pollutants and acute health effects," THE LANCET Vol. 345 (April 8, 1995), pg. 923.

[3] National Research Council, National Academy of Sciences, AIRBORNE PARTICLES (Baltimore, Md: University Park Press, 1979), pgs. 108, 110.

[4] National Research Council, cited above, pg. 1.

[5] D.W. Dockery and C.A. Pope III, cited above, pgs. 113, 116.

[6] C. Arden Pope III and others, "Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults," AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE Vol. 151 (1995), pgs. 669-674.

[7] National Research Council, cited above, pg. 143.

[8] National Research Council, cited above, pg. 139.

[9] For example, see Karl Popper, THE LOGIC OF SCIENTIFIC DISCOVERY (London: Hutchinson, 1959), chapters 6 and 7. Thanks to Carolyn Raffensperger for this.

Descriptor terms: air pollution; fine particles; fossil fuels; coal; oil; automobiles; trucks; buses; electric power; bifs; morbidity; mortality; statistics; studies; pm10; lung disease; philosophy of science; scientific certainty; regulation;