ISSN:1047-3289 *J. Air & Waste Manage. Assoc.* **57**:650–651
DOI:10.3155/1047-3289.57.6.650
Copyright 2007 Air & Waste Management Association

Will the Circle Be Unbroken: A History of the U.S. National Ambient Air Quality Standards

Although U.S. air quality is far from perfect, many citizens take for granted that the air they breathe is much cleaner than in other parts of the world, especially in developing countries and global megacities.[1,2] This was not always the case. Soot-filled industrial cities of the East and Midwest blackened skies in the early part of the 20th century,[3] and photochemical smog received widespread recognition during the latter half of the 1900s.[4–7] Emissions were first detected, and regulated, by sight,[8,9] and "smoke readers" are still being trained to enforce opacity regulations. By 1950, visible emissions from many industrial sources were controlled, although urban and regional hazes were still observed,[10,11] and the effects of different air pollutants on health were being discovered.[12–17] The development and application of ambient air quality measurement systems allowed concentrations and exposures to be quantified,[18–20] which allowed different pollution levels to be better correlated with adverse health impacts[21–29] and other undesirable consequences.[11,30]

By the late 1960s, it was evident that existing technology did not allow emission controls on large stationary sources to effectively attain healthful levels in ambient air. It was also evident that local agencies, and even state governments, had neither the resources nor the legislative authority to make needed improvements. The Clean Air Act (CAA) amendments of 1970 changed all of this by establishing the U.S. Environmental Protection Agency (EPA) and creating National Ambient Air Quality Standards (NAAQS) to protect public health and welfare without consideration to cost.

The 37th Annual A&WMA Critical Review[31] traces the regulatory history of U.S. air pollution from the beginning of the 20th century to the present. The review divides this progress into four segments: (1) the smoke era, 1900–1950; (2) the foundation of air quality management, 1951–1960; (3) the race to the top, 1961–1970; and (4) the NAAQS era, 1971 to present. The author, John D. Bachmann, delves into the historical literature to construct a bleak picture of urban air quality at the turn of the century. Lacking adequate measurements, databases, and dedicated scientific journals, he found much of this information buried in old newspaper clippings, obscure reports, and personal memoirs. Nevertheless, the review identifies how early excesses resulted in community, and eventually political, action to reduce emissions. Much of this was accomplished through fuel switching and improved combustion conditions, but the focus was on emission sources rather than human exposures.

The 1950s included the discovery of photochemical smog in Los Angeles,[4] with the recognition that large industrial emitters were not the only causes of adverse pollution levels. The growing use of the private automobile resulted in large direct emissions of gaseous precursors that could react in the atmosphere to produce unhealthful levels of ozone (O_3), nitrogen dioxide (NO_2), and fine particulate matter (PM). Because vehicles were manufactured on a national, and now global, scale, some form of federal regulation was needed for this and other sources. This realization led to the CAA amendments of 1970, 1977, and 1990 that dominate most of the U.S. air quality management effort.

Judith C. Chow studying air pollution damage to antiquities.

The review concludes that, despite some missteps and lost opportunities, the core elements that constitute the current U.S. air quality management system are good and worthy of emulation elsewhere. The system allows for continual improvement by re-evaluating the NAAQS and their attributes at regular intervals. It permits a division of labor among federal, state, and local entities that can better address problems associated with different spatial scales and regional differences in emissions and geography. It allows for participation of all segments of society, down to the individual citizen who can seek redress within the U.S. legal system. It encourages research and innovation by demanding healthful levels regardless of cost or the current status of emission reduction technologies. The review also identifies some aspects of the CAA that are not so worthy of emulation (e.g., complexity, inability to respond rapidly) and that have been superseded by more effective measures (e.g., emissions trading).

Bachmann, currently principal of Vision Air Consulting, LLC, in North Carolina, recently retired as associate director for science/policy and new program initiatives at EPA's Office of Air Quality Planning and Standards (OAQPS). He joined EPA in 1974, where for 32 years he integrated science and policy issues to improve both the

relevance of EPA's research programs as well as the credibility of its regulations. As a first-hand participant in and observer of many of the key NAAQS and air quality management developments between 1974 and 2007, Bachmann is well qualified to author this review. He participated in the early development of the NAAQS review process and was a key author of the first staff papers on PM and sulfur oxides. His early work integrating air science/policy issues continued through work on: the 1990 CAA amendments, regional haze, acid rain, air toxics, regional O_3 control, market-based multipollutant controls for power generation, and all subsequent reviews of the PM NAAQS.

A&WMA members and interested parties are invited to read, attend, and comment on the 37th Annual Critical Review at the 100th anniversary meeting in Pittsburgh, PA, on Wednesday, June 27, 2007, from 8:00 a.m. to 11:30 a.m. EDT. As always, the review presentation will be followed by comments from invited discussants: (1) Howard Feldman, director of regulatory and scientific affairs for the American Petroleum Institute[32]; (2) Ms. Janice Nolan, director of national policy for the American Lung Association, North Carolina[33]; (3) Dr. Barry R. Wallerstein, executive officer of the South Coast Air Quality Management District (SCAQMD)[34]; and (4) Dr. John G. Watson, research professor at the Desert Research Institute (DRI)[35] and chair of the National Academy of Engineering's Committee on Energy and Air Quality Futures in the United States and China.

The discussants will provide different perspectives, and agree or disagree with the conclusions and recommendations of Bachmann and with each other. They will identify additional issues and offer new information. Comments also will be accepted from the floor and from written submissions to the Critical Review Committee Chair. The Chair will condense and summarize these points in the October issue of the *Journal*. Members are encouraged to suggest topics and authors for future critical reviews and to apply for membership on the Critical Review Committee to assist with the process.

Critical Review Committee Chair (2001–2008)
Judith C. Chow; e-mail judy.chow@dri.edu

Critical Review Committee Members

Pratim Biswas	Peter Mueller
Delbert Eatough	Tom Overcamp
Howard Ellis	John Watson
Charles McDade	Chang-Yu Wu

REFERENCES

1. Molina, M.J.; Molina, L.T. Critical Review: Megacities and Atmospheric Pollution; *J. Air & Waste Manage. Assoc.* **2004**, *54,* 644-680.
2. Chow, J.C.; Watson, J.G.; Shah, J.J.; Kiang, C.S.; Loh, C.; Lev-On, M.; Lents, J.M.; Molina, M.J.; Molina, L.T. 2004 Critical Review Discussion: Megacities and Atmospheric Pollution; *J. Air & Waste Manage. Assoc.* **2004,** *54,* 1226-1235.
3. Stradling, D. Smokestacks and Progressives: Environmentalists, Engineers, and Air Quality in America, 1881–1951; Johns Hopkins University Press: Baltimore, MD, 1999.
4. Haagen-Smit, A.J. Chemistry and Physiology of Los Angeles Smog; *Ind. Eng. Chem.* **1952**, *44,* 1342-1346.
5. Mader, P.P.; MacPhee, R.D.; Lofberg, R.T.; Larson, G.P. Composition of Organic Portion of Atmospheric Aerosols in the Los Angeles Area; *Ind. Eng. Chem.* **1952**, *44,* 1352-1355.
6. Littman, F.E.; Ford, H.W.; Endow, N. Formation of Ozone in the Los Angeles Atmosphere; *J. Air Poll. Control Assoc.* **1956**, *6*, 171.
7. Rogers, L.H.; Renzetti, N.A.; Neiburger, M. Smog Effects and Chemical Analysis of the Los Angeles Atmosphere; *J. Air Poll. Control Assoc.* **1956**, *6*, 165.
8. Ensor, D.S.; Pilat, M.J. Calculation of Smoke Plume Opacity from Particulate Air Pollution Properties; *J. Air Poll. Control Assoc.* **1971**, *21,* 496-501.
9. Griebling, R.T. Maximilien Ringelmann—Man of Mystery; *Air Repair* **1952**, *2,* 4-6.
10. Neiburger, M.; Wurtele, M.G. On the Nature and Size of Particles in Haze, Fog, and Stratus of the Los Angeles Region; *Chem. Rev.* **1949**, *44,* 321-335.
11. Watson, J.G. Visibility: Science and Regulation; *J. Air Waste & Manage. Assoc.* **2002**, *52,* 628-713.
12. Klotz, O.; White, W.C. Papers on the Influence of Smoke on Health. Smoke Investigation Bulletin No. 9; Mellon Institute of Industrial Research, University of Pittsburgh: Pittsburgh, PA, 1914.
13. Furman, B. Government Spurs Poisoned Air Study. Report on Donora, PA, Calls It National Problem—Staten Island Pollution Sifted. Federal Help Is Provided. Public Health Service Asking $250,000 More for Work as 15 Cities Request Aid; *The New York Times* **1949**, 10-14.
14. Schrenk, H.H.; Heimann, H.; Clayton, G.D.; Gafafer, W.M.; Wexler, H. Air Pollution in Donora PA, Epidemiology of the Unusual Smog Episode of October 1948; Public Health Bull 306; U.S. Government Printing Office: Washington, DC, 1949.
15. Mills, C.A. Respiratory and Cardiac Deaths in Los Angeles Smogs; *Am. J. Med. Sci.* **1957**, *233,* 379-386.
16. Breslow, L.; Goldsmith, J.R. Health Effects of Air Pollution; *Am. J. Public Health* **1958**, *48,* 913-917.
17. Zeidberg, L.D.; Schueneman, J.J.; Humphrey, P.A.; Prindle, R.A. Air Pollution and Health: General Description of a Study in Nashville, Tennessee; *J. Air Poll. Control Assoc.* **1961**, *11,* 289-297.
18. Katz, M. Critical Review: Advances in the Analysis of Air Contaminants; *J. Air Poll. Control Assoc.* **1980**, *30,* 528-557.
19. Chow, J.C. Critical Review: Measurement Methods to Determine Compliance with Ambient Air Quality Standards for Suspended Particles; *J. Air & Waste Manage. Assoc.* **1995**, *45,* 320-382.
20. Watson, J.G.; Thurston, G.D.; Frank, N.H.; Lodge, J.P.; Wiener, R.W.; McElroy, F.F.; Kleinman, M.T.; Mueller, P.K.; Chow, J.C. 1995 Critical Review Discussion: Measurement Methods to Determine Compliance with Ambient Air Quality Standards for Suspended Particles; *J. Air & Waste Manage. Assoc.* **1995**, *45,* 666-684.
21. Biswas, P.; Wu, C.Y. 2005 Critical Review: Nanoparticles and the Environment; *J. Air & Waste Manage. Assoc.* **2005**, *55,* 708-746.
22. Chow, J.C.; Watson, J.G.; Mauderly, J.L.; Costa, D.L.; Wyzga, R.E.; Vedal, S.; Hidy, G.M.; Altshuler, S.L.; Marrack, D.; Heuss, J.M.; Wolff, G.T.; Pope, C.A., III; Dockery, D.W. 2006 Critical Review Discussion—Health Effects of Fine Particulate Air Pollution: Lines that Connect; *J. Air & Waste Manage. Assoc.* **2006**, *56,* 1368-1380.
23. Ferris, B.G., Jr. Critical Review: Health Effects of Exposure to Low Levels of Regulated Air Pollutants: a Critical Review; *J. Air Poll. Control Assoc.* **1978**, *28,* 482-497.
24. Goldstein, B.D. Toxic Substances in the Atmospheric Environment—a Critical Review; *J. Air & Waste Manage. Assoc.* **1983**, *33*, 454-467.
25. Lighty, J.S.; Veranth, J.M.; Sarofim, A.F. Critical Review: Combustion Aerosols: Factors Governing Their Size and Composition and Implications to Human Health; *J. Air & Waste Manage. Assoc.* **2000**, *50,* 1565-1618.
26. Mukerjee, D. 1998 Critical Review—Assessment of Risk from Multimedia Exposures of Children to Environmental Chemicals; *J. Air & Waste Manage. Assoc.* **1998**, *48,* 483-501.
27. Pope, C.A., III; Dockery, D.W. Health Effects of Fine Particulate Air Pollution: Lines that Connect; *J. Air & Waste Manage. Assoc.* **2006**, *56*, 709-742.
28. Vedal, S. Critical Review—Ambient Particles and Health: Lines that Divide; *J. Air & Waste Manage. Assoc.* **1997**, *47,* 551-581.
29. Watson, J.G.; Wyzga, R.E.; Burnett, R.T.; Vostal, J.J.; Romieu, I.; Chow, J.C.; Holcombe, J.T.; Lipfert, F.W.; Marrack, D.; Thompson, R.J.; Vedal, S. Ambient Particles and Health—Lines that Divide: 1997 Critical Review Discussion; *J. Air & Waste Manage. Assoc.* **1997**, *47*, 995-1008.
30. Hidy, G.M. Critical Review: Source Receptor Relationships for Acid Deposition: Pure and Simple; *J. Air Poll. Control Assoc.* **1984,** *34*, 518-531.
31. Bachmann, J.D. 2007 Critical Review—Will the Circle Be Unbroken: a History of the U.S. NAAQS; *J. Air & Waste Manage. Assoc.* **2007**, *57*, 652-697.
32. American Petroleum Institute Home Page; available at *http://www.api.org/* (accessed 2007).
33. American Lung Association Home Page; available at *http://www.lungusa.org/* (accessed 2007).
34. South Coast Air Quality Management District (SCAQMD) Home Page; available at *http://www.aqmd.gov/* (accessed 2007).
35. Desert Research Institute (DRI) Home Page; available at *http://www.dri.edu* (accessed 2007).