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Air Quality Management SubCommittee
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Challenges for Air Quality Management – A Look Ahead

Over the past thirty years, air quality management programs in the United States have made significant progress in a number of key areas. For instance, the number of areas out of attainment with air quality standards has declined dramatically; air quality standard violations of several pollutants, including sulfur dioxide, nitrogen oxide, carbon monoxide and lead, have been nearly eliminated; and the concentrations of the other criteria pollutants have dropped considerably in much of the country. This progress has resulted in substantial public health benefits and economic savings, during a period of sustained growth in the economy, energy production, vehicular travel, and population (Figure 1).

Yet a number of serious air quality management challenges remain, from the areas with lingering nonattainment problems with ozone and particulate matter to heightened awareness and concern over exposure to air toxics; from the relatively high background levels of air pollution (some of it from international transport) to the effect of air pollution on climate change – and vice versa. In addition, the economic and societal factors that influence air pollution to continue to grow. To be effective, future air quality management will need to address all of these challenges.

Continued Nonattainment Problems: Ozone and Particulate Matter

Despite the implementation of the federal NOx SIP Call, the Clean Air Interstate Rule (CAIR), federal mobile source rules, and various state, local, and tribal initiatives, our air quality modeling forecasts suggest that a number of areas would remain out of attainment with the current national ambient air quality standards for ozone and particulate matter in 2015 even after such programs are implemented (Figure 2). The number of residual non-attainment areas would be increased if the proposed revisions to the PM2.5 standards are promulgated. This attainment 'gap' must be addressed by the AQM system between now and 2020.

CAIR, which aims to cut NOx and PM emissions from electric generating sources by around 60 percent by 2015, along with tighter federal mobile source rules, are still predicted to leave 14 areas in nonattainment with either $PM_{2.5}$ or ozone standards in 2015. These nonattainment areas, according to EPA modeling, are expected to be concentrated in California and in a geographic region between Michigan and Alabama, including Atlanta. The common thread in eastern projected nonattainment areas appears to be higher regional $PM_{2.5}$ and ozone levels. For PM, this regional problem is expected to be exacerbated by concentrations of local sources of direct PM emissions such as industrial facilities.

These lingering nonattainment areas are of particular concern given the increased scientific evidence which has emerged over the past decade linking ozone and particulate matter exposure to a wide range of serious human health effects. In addition to the long-recognized effects of ozone on lung function, more recent scientific studies have linked ozone to mortality (particularly among the elderly), hospital admissions for respiratory ailments (particularly among children), school absenteeism, and incidence of asthma.

Likewise, scientists now better understand the very serious health effects associated with fine particulate matter exposure. Numerous studies had previously linked PM to a wide range of cardiovascular and respiratory health problems; new studies demonstrate associations between short-term exposure and various indicators of PM and cardiopulmonary mortality, hospitalization and emergency department visits, respiratory symptoms, and the development of lung capacity in children. The evidence now shows an association with cardiovascular health problems, including increased heart attacks, development of atherosclerosis, and changes in blood chemistry. Children and the elderly, as well as people with pre-existing cardiovascular or respiratory diseases such as asthma, are particularly susceptible to health effects caused by PM.

One of the difficulties in addressing particulate pollution is the wide range of sources that produce direct and/or secondarily formed PM, from diesel engines in on-road and off-road vehicles, to electric generating facilities, industrial combustion and process sources, and residential woodstove use. Moreover, in some areas, a substantial fraction of particulate matter pollution emanates upwind and contributes to local problems. These background levels of pollution are extremely hard for state, local, and tribal air quality planners to address, yet they must be considered.

Another challenge for air quality management that has surfaced in recent years involves the speciation of particulate matter; that is, the various types of particles (e.g., sulfates, nitrates, carbon, and crustal). A number of key questions remain: which types of particles or source types are most toxic? Which contribute to the most serious public health, climate, and ecosystem effects? The answers to these questions may assist air quality managers hone strategies to address the greatest threats among particulates.

As the NRC report recognized, an emerging area of concern for both ozone and particulate matter is the growing evidence that there is no clear threshold, or level below which no serious health impacts will occur. Studies of both pollutants suggest that there may be no threshold, and even low level exposures to ozone or PM may be harmful to human health.

The most recent scientific information on the health and environmental effects of particles, ozone, and related precursors suggests that the standards and programs for these pollutants will likely remain at current or even more restrictive levels for the foreseeable future. Developing strategies to attain and maintain current or tighter standards in the long-term will pose a significant challenge for the air quality management system. It appears likely that this will require new and innovative emissions reductions strategies; drawing in under-regulated emissions sources, such as marine vessels, locomotives, and grandfathered industrial facilities; instituting transportation control measures to address increasing vehicle use; and initiating regional planning efforts to engage in a more holistic approach to air quality management.

Air Toxics

Historically, the air quality management system has not allocated the same level of resources to air toxics control and management efforts as compared to ozone and PM. While ozone and PM programs have resulted in the reduction of a number of toxic components and precursors, residual air toxics problems still exist on local, regional, and even global scales, and the NRC report and recent National Air Toxics Assessment (NATA) work suggest that exposure to various air toxics pose significant risks to public health. The most recent NATA report suggests a background cancer risk for much of the nation in the range of between 1 and 25 in a million, with much of that coming from a single compound, benzene. Moreover, the areas of higher risk tend to occur in populated urban areas and in the eastern U.S., which also tend to overlap the ozone and PM non-attainment areas.

It is useful to separate air toxics into two categories:
1) *persistent bioaccumulative toxics* such as mercury and other heavy metals, dioxins, and pesticides. Such toxics often have a long atmospheric lifetime and are prone to long distance transport (hundreds to thousands of miles) and multimedia pathways to human exposure, often through ingestion of contaminated foods that have concentrated substances deposited from atmospheric transport. To a large extent, dealing with these toxics is a matter of addressing the sources – including those located abroad – that contribute to the buildup of background concentrations.

2) *high-risk species* with short-to-medium term atmospheric lifetimes. These ‘traditional’ air toxics have more of a local impact through direct inhalation and are much more likely than bioaccumulative pollutants to pose environmental justice concerns. These pollutants, particularly those from stationary sources from industrial to area in size, have been the subject of Section 112 regulations. Petroleum refining, mineral extraction and smelting operations, hazardous waste combustion, and various other source categories have all been the subject of Section 112 “Maximum Achievable Control Technology” regulations. In many urban areas, “traditional” air toxics exposures are dominated by mobile source emissions. Toxic “hot spots” often occur in predominantly low-income communities situated adjacent to major highways, congested roads, transit depots, marine and rail terminals, as well as near commercial and industrial sources.

Emerging information points to a potential overlap between traditional air toxics and PM concerns. A growing body of evidence suggests both exposures and health effects of concern for populations who spend significant time on or near heavily-traveled roadways. The issue may be related to direct localized emissions of ultrafine, fine, or even coarse particles, associated organic or inorganic gaseous tailpipe emissions, or multiple factors, including toxic subcomponents of such emissions. While this area is the subject of increasing research activity, it is important to note that National Ambient Air Quality Standards and State Implementation Plans have not developed effective strategies to deal with micro-environments such as these. Instead, 'hot-spots' would require different and innovative management techniques that could include transportation planning, city planning, and a variety of mitigating actions (e.g., diesel retrofits).

Other Effects of Air Pollution/Interactions

In addition to addressing the lingering nonattainment problems for ozone and PM and ongoing air toxics problems, air quality management must also confront other effects of air pollution including climate change and ecosystem impacts.

Climate Change

Warmer temperatures and air pollution experience a dynamic relationship, as each may exacerbate or mitigate the other. For instance, rising temperatures cause greater ozone production, so a warming earth may lead to more ozone pollution in many areas. In addition, warmer weather directly would affect energy demand: as temperatures rise, so too does electricity use. More electricity use would lead to greater utilization of existing power plants, or (eventually) to more power plants. In turn, this would lead to more NO_x, SO_x, PM, VOC and CO emissions in the summer. A warmer winter may also lead to less energy demand, which would help in areas where PM2.5 problems are dominated by woodsmoke and related wintertime heating emissions.

Another possible—though not certain—impact of global warming is an increase in the frequency of wildfires, generally because of hotter and drier conditions or because of other consequences of climate change (for instance, climate change may cause greater seasonal variations in rainfall in certain locations. More rain may lead to more vegetative growth; if hotter and drier conditions prevail as the season progresses, the trees and plants may become a tinderbox and cause more extensive wildfires because of their greater density.) An increase in wildfires will have a direct impact on air quality, as fires emit various air pollutants, such as $PM_{2.5,}$ SO_2, NO_x, and a host of hazardous air pollutants including benzene, toluene, and polycyclic organic matter.

Air quality linkages to climate work in the other direction as well, because some air pollutants may affect global warming For instance, while carbon dioxide and tropospheric ozone help to warm the globe, sulfates resulting from sulfur dioxide emissions serve to cool it. A number of scientists believe that the relatively cool period at the beginning of the second half of the twentieth century was tied to an increase in the emission of sulfates.

More recently, scientists have begun to focus on the regional and local scale effects of air pollutants on weather and climate, and here the effects may go beyond the traditional focus on simple warming and cooling by aerosols and gases. One of the key points is illustrated by recent global simulation modeling done by Mark Jacobson of Stanford University. He reports two important findings. First, reducing particulate matter concentrations in the Eastern U.S. may produce warming, since sulfates cause cooling by increasing cloud cover that reduces sunlight reaching the ground and increases that reflected into space. Second, Jacobson builds into his model findings that the increased cloudiness associated with the sulfate particles comes with a decrease in cloud droplet size, which results in reduced precipitation. This illustrates an important potential regional effect of air pollution, namely that air pollution can affect climate on a regional scale, and some of the effects – reduced precipitation – may be problematic. Recent results from researchers at the Desert Research Institute suggest that atmospheric sulfates may be reducing the amount of snow pack accumulation in the Rocky Mountains, potentially aggravating drought conditions. These results illustrate the importance of examining the unexpected feedbacks between air pollution and climate.

The bottom line is that understanding the connections between global warming and air quality management is not easy, and there is great uncertainty, particularly over the timing, extent, scale and localized impact of these potential effects. Nonetheless, the effect of climate change on air quality and vice versa is far too important a concern to ignore. For air quality managers, these multifaceted linkages could include the following: 1) it is vital to develop a system that attempts to anticipate the potential impacts of forecast climate changes on air quality 2) The AQM system must anticipate and provide for the possible need for conventional and innovative multipollutant programs that address both conventional air pollutants as well as greenhouse gases; 3) Future programs may also need to address the effects of air pollution on regional or local climate in the US.

Environmental Effects

Historically, Federal and State air quality management programs have not focused significant attention on environmental effects of air pollution, including effects on terrestrial and aquatic ecosystems or visibility, as compared to health based programs. As evidence on some of these effects mounted in the 1970s and 1980's Congress amended the Clean Air Act to address visibility in national parks and wilderness areas (Section 169A and B, 1977 and 1990 Amendments) and acid rain (Title IV,1990 Amendments). Both are very significant programs that effected a substantial decline in emissions of SOx and NOx that began with the acid rain program and is expected to continue over the next several decades through the regional haze rule. Nevertheless, the AQM system has not produced much beyond these explicitly mandated environmental programs. Yet, the Act also launched programs to research ecosystem health and it still retains requirements for secondary standards to protect public welfare, including the environment. The NRC AQM report recommended establishing ecosystems as an air quality management priority. It suggested that this would entail, as a first step, implementing a monitoring system to measure ecosystem health. An adequate measurement system would involve not only increasing the current number of measurement locations, but also developing meteorological and exposure models, undertaking risk assessment research and researching the interplay of ecosystems with multiple factors simultaneously, such as air quality, climate, and topography.