Highlights from the Coordinating Research Council's

2019 Mobile Source Air Toxics Workshop

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The 2019 Coordinating Research Council's (CRC) Mobile Source Air Toxics (MSAT) Workshop was held February 4–6 at the California Environmental Protection Agency (CalEPA) Headquarters in Sacramento, CA. This was the ninth in a biennial series of CRC MSAT Workshops, which began in 2002. The purpose of the workshop was to bring together interested parties to review the status and current knowledge regarding mobile source air toxics. The 2019 workshop highlighted the ongoing trend of decreasing emissions and improving air quality in the United States. Despite the significant progress made, further reductions in MSAT emissions and improvement in air quality are needed. One plenary and five technical sessions covered regulatory needs, measurement and modeling of vehicle emissions, air quality and exposure measurements, air quality and exposure modeling, and accountability. The workshop featured 32 oral presentations and six posters with 120 participants. The agenda, final report, and presentations are available on the CRC website at www.crcao.org. Highlights from the sessions follow.

Strategies to reduce mobile source criteria, toxic, and greenhouse gas (GHG) emissions include:electrification of mobility; wider availability of micro-mobility (scooters, bikes), micro-transit, ride-hailing, and car sharing; and better linkages between mass transit and private services. To promote these strategies, more incentives for pooling and disincentives for single-passenger/single-occupant travel may be needed. The strategies could increase pooling, which may increase person miles traveled (PMT), but decrease vehicle miles traveled (VMT).

Figure 1 shows trends of ambient benzene concentrations measured in U.S. cities from 2003 to 2016. As illustrated in Figure 2 (left panel), reductions of MSAT emissions in California between 1990 and 2012 have lowered estimated cancer risks by 76–90%. Yet, unacceptable risk remains. This is particularly true in environmental justice areas where levels of pollution typically exceed those in surrounding areas (see Figure 2, right panel). In response to Assembly Bill 617 the California Air Resources Board (CARB) has established the Community Air Protection Program to reduce exposures in communities most affected by air pollution by increased monitoring at the local scale. On a national level, the latest update of the U.S. National Emissions Inventory (NEI) in 2018 provided detailed estimates of air emissions for criteria air pollutants and hazardous air pollutants for the period 2014–2017.

Regulatory Needs

It seems likely that emissions of mobile source toxics and criteria air pollutants will remain an issue for the foreseeable future. The mobile source contribution is particularly pronounced in local hotspots such as railyards, ports, and near major road intersections. Areas of future research focus include secondary organic aerosol (SOA) and brake and tire wear. In California, CARB and local air districts have launched a community air protection program and are jointly developing new approaches combining finer-scale air quality data collection and community emissions inventories to support local strategy development. Fragmented and sometimes overlapping authority provides challenges for regulating mobile sources: international authority for aircraft and ships; federal authority for motor vehicles, off-road equipment, and locomotives; and state (CARB) authority for California new engines and fuels. Local air quality management districts have limited authority for in-use fleets serving governments and some large facilities (e.g., warehouses).

Measurements and Modeling of Vehicle MSAT Emissions

On-road vehicle emissions were measured and modeled. Cold temperatures were found to substantially increase volatile and semi-volatile organic carbon (VOC, SVOC) emissions in gasoline direct injection (GDI) vehicles. The U.S. Environmental Protection Agency (EPA) is developing

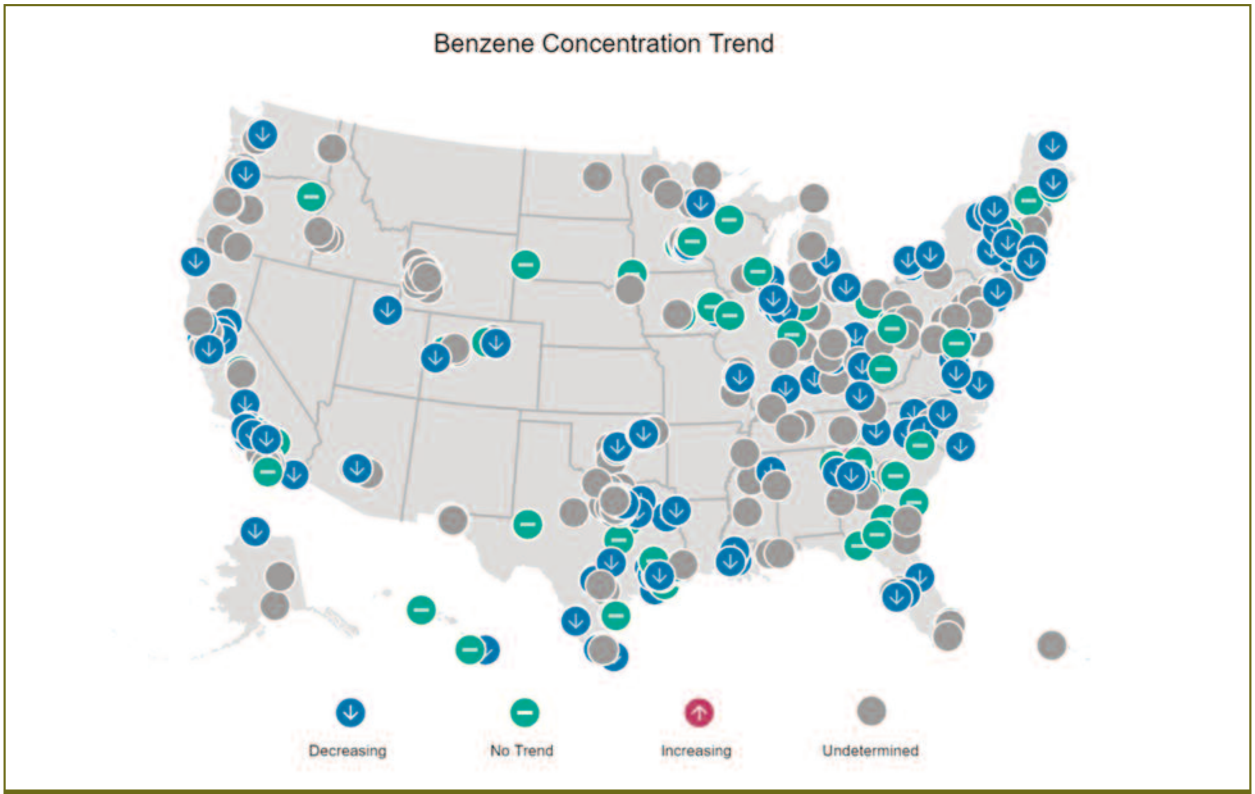

Figure 1. U.S. ambient benzene concentrations, 2003–2016.

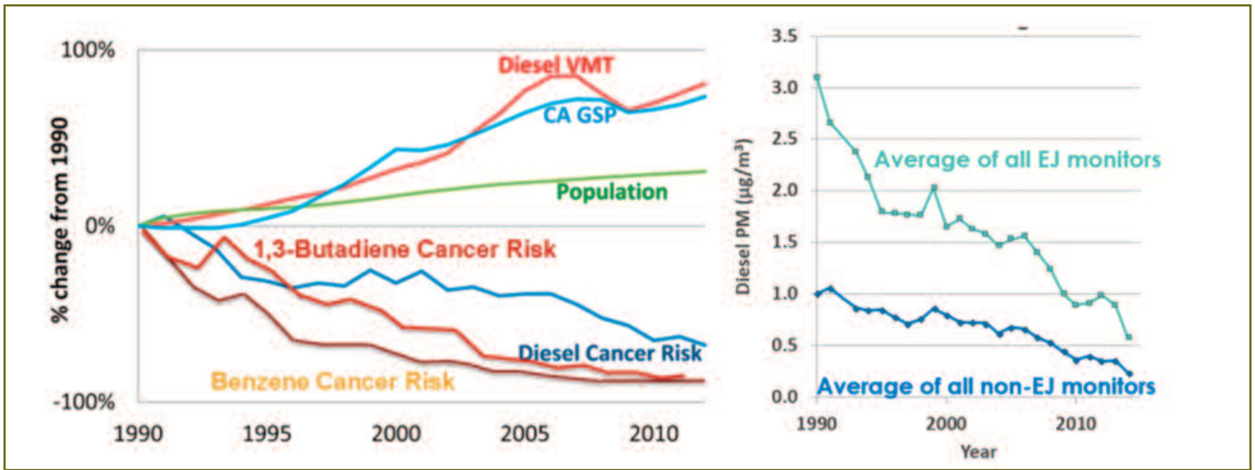

Figure 2. California MSAT emissions1990–2012 (left panel); pollution levels in environmental justice areas (right panel).

volatility-based emission profiles for use in air quality models. Emissions from current technology GDI vehicles showed higher potential SOA formation with higher aromatic fuel content and an ethanol reinforcing effect was found for fuels with a high particulate matter index (PMI).

Emissions from port fuel injected (PFI) vehicles using E10 fuel decreased with increasing ambient temperature. The phenomenon was more pronounced for oxygenated species. The first in-use light-duty gasoline vehicle study of isocyanic acid (HNCO) and hydrogen cyanide (HCN) emission factors found HNCO emissions about two times greater, and HCN emissions much lower, than those in dynamometer studies. A small fraction of vehicles account for a large fraction of HNCO/HCN emissions.

One study developed a cabin air quality index (CAQI), which may enable customers to choose vehicle heating ventilation and air conditioning (HVAC) systems that reduce their exposure to pollutants. In-use heavy-duty truck emissions measured near the Caldecott Tunnel in California and in the Ft. McHenry Tunnel in Baltimore show large decreases in emissions of oxides of nitrogen (NOx) and PM over the past 10 years. Estimates from EPA's Motor Vehicle Emission Simulator (MOVES2014) compare well with the tunnel observations.

Air Quality and Exposure Measurements

A suite of different measurement techniques are being used to monitor air quality. Ground measurements provide detailed air quality information but lacks spatial resolution. Satellite remote sensing provides broad spatial coverage, fills spatial gaps in ground monitoring networks, and can track broad progress on various air quality management strategies.

Cooking and traffic emissions are the main sources of spatial variability in urban air pollution. Local emissions of organic aerosol and black carbon are the major contributors for PM spatial variations. Trucks are still an important source of emissions in West Oakland, CA. The centrally located monitoring site understates black carbon concentrations observed at many local monitoring sites. In the Raleigh, NC, area, biogenic emissions appear to dominate precursor emissions that lead to SOA formation, even near a busy highway, although vehicles also contribute to substantial emissions of SOA precursors. Temperature-driven partitioning has implications for primary emission exposure and SOA formed from SVOCs. Roadside vegetation can provide significant reductions in local air pollution. EPA and CARB have developed recommendations to help design and maintain roadside vegetation for air quality benefits.

Modeling of on-road diesel PM (DPM) is being conducted in California. A methodology is being developed to spatially allocate and graphically illustrate vehicle emissions on each roadway to identify localized pockets of high DPM concentrations.

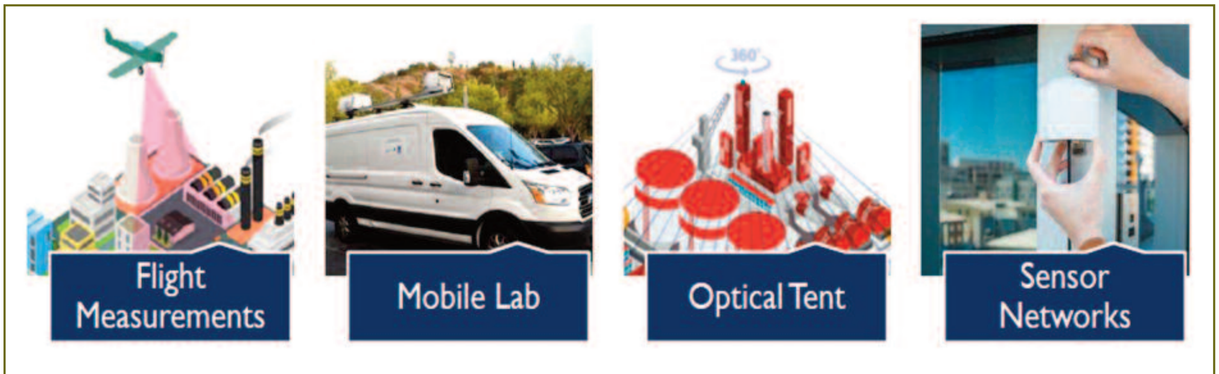

Figure 3. MATES V advanced monitoring components.

Air Quality and Exposure Modeling

Exposure modeling was performed for various spatial levels for various air quality components to determine health risks. Using the 2014 National Air Toxics Assessment (NATA), average U.S. lifetime cancer risks from air toxics were estimated to be approximately 30 in 1 million. Formaldehyde is the highest national risk driver based on estimated cancer risk. Pollutants come from manmade sources (e.g., facilities or vehicles) and natural sources (e.g., trees). On-road vehicle emissions contribute substantially to ambient benzene and polycyclic aromatic hydrocarbon concentrations in Canada. Contributions vary widely among locations and between seasons.

Significant progress has been made in the ability to simulate and model ultrafine particles ($PM_{0.1}$) in regional and urban scales. Nucleation is a major source of ultrafine particles during photochemically active periods. Regional chemical transport models can predict the major spatial and time trends in ultrafine particle concentrations. In some California cities, mobile sources do not dominate ultrafine particle contributions.

Accountability

Accountability studies assess the effectiveness of regulatory actions. There have been large reductions (~98%) in PM and NOx emission rates for 2007 and later heavy-duty engines compared to pre-1990 model years. California has accelerated replacement of older engines with newer engines equipped with diesel particulate filters (DPFs) and selective catalytic reduction (SCR). However, expected PM emission reductions have not been fully realized because some heavy-duty vehicles are operating without a DPF, and because some DPF-equipped engines have performance shortfalls.

The South Coast Air Quality Management District (SCAQMD) Multiple Air Toxics Exposure Study IV (MATES IV) found DPM contributes ~70% of estimated total air pollution cancer risk. DPM emissions were reduced by 66% between 2005 and 2012. Existing regulations are expected to reduce DPM from trucks by another 90% between 2012 and 2021. MATES V will include advanced monitoring components, illustrated in Figure 3, that will enable the creation of detailed air toxics maps.

Reductions in air pollution from goods movement actions and subsequent improvements in health outcomes for 23,000 California Medicaid enrollees were studied. Enrollees with asthma in port areas or places within 500 meters of truck-permitted freeways experienced greater reductions in emergency department visits than enrollees further away from freeways.

Summary

There has been great success in reducing MSAT emissions over the past several decades despite large increases in VMT. Accelerated fleet turnover of conventional technology vehicles, influx of revolutionary vehicle technologies such as self-driving and zero-emission vehicles, and strategies for various spatial levels will ensure that the trends of decreased MSAT emissions and human exposure to the emissions will continue in coming decades. **em**

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