An analysis of the spatial distribution of O₃ and its precursors during summer in the urban atmosphere of Riyadh, Saudi Arabia

Badr H. Alharbi, Abdulilah K. Alduwais* , Abdurahman H. Alhudhodi

National Center for Environmental Technology, King Abdulaziz City for Science and Technology, P.O. Box 6086, Riyadh 11442, Saudi Arabia

ABSTRACT

Ozone (O₃) concentration, along with the concentrations of 10 precursors (acetone, toluene, ethylbenzene, benzene, xylenes, styrene, cyclohexane, NO, NO₂, and CO), were measured and characterized at 16 locations in Riyadh, the capital city of Saudi Arabia, for the period of May through August 2012. The results showed that concentrations of all O₃ precursors were high in central and industrial areas, owing mainly to road traffic volume and industrial emissions. Except for benzene, all pollutants featured a skewed distribution, which indicates that they might occasionally be influenced by contiguous sources of air pollution and/or by emissions from heavy air polluters. The benzene distribution does not follow this behavior, possibly due to the shortage of substantial stationary benzene emitters. Also, the considerable difference between the median and the mean of both xylene and toluene distributions suggests local emission impacts in Riyadh. O₃ concentrations averaged 34.59 ± 24.17 ppb and were a maximum of 277.47 ppb, occasionally violating the 1-h national standard (120 ppb) and frequently exceeding World Health Organization (WHO) and United States Environmental Protection Agency (EPA) standards.

© 2017 Turkish National Committee for Air Pollution Research and Control. Production and hosting by Elsevier B.V. All rights reserved.

1. Introduction

Urban air quality is considered one of the most important elements affecting the quality of life within cities. Transportation problems, such as traffic jams, industrial activities, and unbalanced urban planning, lead to an increase in emissions that play a major role in degrading air quality (Silva and Mendes, 2012). As a result of worldwide urban expansion at rapid rates, urban air pollution has become a major health, economic, and social concern. Air pollution in urban areas can create a complex mixture of hazardous compounds within the urban atmosphere, which has the potential to induce acute and chronic health responses in children and people with a history of cardiovascular or respiratory disease (Diaz-Pendon et al., 2004; Krzyzanowski et al., 2002; Martins et al., 2012; Pope and Dockery, 2006).

According to the World Health Organization (WHO), in 2012, air pollution was responsible 3.7 million deaths globally, or 6.7% of all deaths worldwide (WHO, 2012). According to the Organization for Economic Co-operation and Development (OECD), air pollution is projected to be the major cause of mortality by the year 2050 (OECD, 2012). Air quality standards and regulations are becoming more important in protecting the health of humans and their surrounding environment (Marenco et al., 1994; Kasibhatla et al., 1996).

As a result of fuel combustion and biomass burning, anthropogenic activities, including automotive and industrial sectors, emit nitrogen oxides (NOₓ), volatile organic compounds (VOCs), and carbon monoxide (CO) into the atmosphere. These emissions cause elevated ozone (O₃) concentrations, particularly in areas located downwind of the emission sources. The newly formed O₃ is a secondary pollutant and a highly oxidative compound that endangers public health through its various negative impacts, including oxidizing lung tissue, increasing mortality and respiratory morbidity rates, damaging rubber, nylon, and other materials, and affecting secondary chemistry in the atmosphere (Cotgreave, 1996; Geddes and Murphy, 2012; Seinfeld, 2004; Tetteh et al., 2015).

Although environmental protection bodies around the world have established air quality standards to maintain air pollution within acceptable levels, there is no concentration of O₃ associated with negligible health risk (McDonnell et al., 1993).

O₃ is formed in the troposphere when VOCs and CO are photochemically oxidized in the presence of NOₓ. Such reactions

* Corresponding author.
E-mail address: aaldowais@kacst.edu.sa (A.K. Alduwais).

Peer review under responsibility of Turkish National Committee for Air Pollution Research and Control.

http://dx.doi.org/10.1016/j.apr.2017.02.005

1309-1042/© 2017 Turkish National Committee for Air Pollution Research and Control. Production and hosting by Elsevier B.V. All rights reserved.

Please cite this article in press as: Alharbi, B.H., et al., An analysis of the spatial distribution of O₃ and its precursors during summer in the urban atmosphere of Riyadh, Saudi Arabia, Atmospheric Pollution Research (2017), http://dx.doi.org/10.1016/j.apr.2017.02.005
Reactions (1) through (4) show the two main reactants involved in \( O_3 \) production, \( \text{VOCs} \) and \( \text{NO}_x \). The reaction between \( \text{NO} \) and a peroxide radical \( (\text{RO}_2) \), either organic or hydro (\( \text{HO}_2 \)), leads to the formation of \( \text{NO}_2 \). These peroxide radicals come from atmospheric

\[
\begin{align*}
\text{OH} + \text{VOCs} (+\text{O}_2) &\rightarrow \text{RO}_2 + \text{H}_2\text{O}, \quad (1) \\
\text{RO}_2 + \text{NO} &\rightarrow \text{NO}_2 + \text{RO}, \quad (2)
\end{align*}
\]

\[
\begin{align*}
\text{NO}_2 + \text{sunlight} (\lambda < 420 \text{ nm}) &\rightarrow \text{NO} + \text{O}, \quad (3) \\
\text{O} + \text{O}_2 &\rightarrow \text{O}_3. \quad (4)
\end{align*}
\]

Fig. 1. Map of Riyadh showing urban limits, the 16 designated \( 12 \times 12 \text{ km} \) cells, air pollutant monitoring points and major emission sources.
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات