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Ambient air pollution by aromatic hydrocarbons in Algiers

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Abstract

The analysis of the C_6–C_{16} semi-volatile organic compounds reveals the presence of numerous aromatic hydrocarbons in the ambient air of Algiers. Three representative sites were chosen for sample collection at roadside, urban background and semi-rural areas. The following major monocyclic aromatic hydrocarbons were found: benzene, toluene, ethylbenzene, (*m*, *p*)- and *o*-xylene, also referred to as BTEX. Near the road traffic, benzene and toluene mean concentrations were 27 and 39 $\mu g\,m^{-3}$, respectively, with benzene concentration values higher than 40 $\mu g\,m^{-3}$ often observed. At the urban site, the benzene concentration often exceeds the European regulatory limit of 10 $\mu g\,m^{-3}$ while the compositional ratios of toluene to benzene and (*m*–*p*) xylene to ethylbenzene are within the typical range of values observed in urban atmospheres worldwide. The seasonal variation indicates a decrease in concentration during summer of the reactive *o*-xylene compound. It is suggested that Algiers' source of high-level air pollution by aromatic hydrocarbons is related to car traffic emissions.

Keywords: Air pollution; Road traffic; BTEX compounds; VOC; Algeria

1. Background

Aromatic hydrocarbons represent a significant fraction of the volatile organic compounds (VOCs) emitted in urban atmospheres by road traffic (Bailey and Eggleston, 1993; Singh et al., 1992; Zielinska et al., 1996; Seila et al., 1989). The use of unleaded gasoline, which is rich in aromatic hydrocarbons, has increased worldwide and the monitoring of these hydrocarbons in urban area has become an important issue. Monocyclic aromatic hydrocarbons (MAH) like benzene have been a prime target for assessment (Brocco et al., 1997; Coursimault et al., 1995; Pfeffer et al., 1995). It has been reported near heavy road traffic that mobile sources account for 75–85% of the benzene emissions of which 70% is from exhaust. The highest emissions are closely related to the use of gasoline in non-catalytic cars (Colls, 1997; Sigsby et al., 1987). Benzene is considered as a carcinogen and heavy alkyl benzenes are precursors of tropospheric ozone. Previous work revealed that road traffic is one of the major sources of ambient air pollution in Algiers (Kerbachi et al., 1998; Boughedaoui et al., 2004). The city of Algiers counts more than 3 million inhabitants with a large car fleet of about six hundred thousands vehicles. This relatively high rate of car use, 200‰ vehicle per capita, is among the highest in developing countries. However, this automobile park is old; nearly 75% of the cars are older than 10 years and has poor maintenance and the present rate of car fleet renewal in Algeria is very low, less than 2% per year. Furthermore, the quasi-totality of this fleet is not equipped with catalytic converters to reduce and oxidize pollutant gases. According to refineries' officials, present gasoline

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content varies from 35% to 40% for aromatics and from 2.5% to 3% for benzene. Extensive and continuous measurements of organic compounds are required to estimate population exposure to potentially hazardous gases and formulate monitoring and control strategies. Until now, there is no report of ambient VOC in urban air in the entire North African region, and this study represents the first attempt to measure, identify and analyse concentrations of VOCs and document levels of air pollution by the aromatic compounds in the ambient air of Algiers. This paper presents results of the aromatic hydrocarbons levels measured at three sites, roadside, urban and semi-rural areas in Algiers.

2. Methods

2.1. Sampling sites

In order to investigate the spatial distribution of VOCs, especially the benzene, toluene, ethylbenzene, (*m*, *p*)-and *o*-xylene (BTEX) compounds, in different areas, three sampling sites have been selected based on their population number and car traffic flow. Two sites (S_1 and S_2) are located in Algiers city and the third one (S_3) is in the suburbs of Algiers. The sampling site S_1 is located in the city centre near a busy street canyon, Boulevard Colonel Amirouche, where high car traffic and pedestrian affluence are observed during all day. The traffic flow at this street is around 14,000 vehicles/day of which about 95% are gasoline propelled and 5% are utility vehicles with diesel combustion. Samples are taken at 2 m of the curb on the windward site of surrounding buildings. The sampling site S_2 is located in a residential area (Kouba) with a high population density. There is no main road with high traffic density or industrial emission sources within 400 m around this site. This site is assumed to represent the urban background air pollution in Algiers. The third sampling site S_3 is located in Reghaia, a small city about 30 km east of Algiers and is considered to represent a semi-rural area (Fig. 1) with a low traffic flow and medium population density.

2.2. Sample collection

A first campaign has been made during November 1996 for VOCs identification in Algiers' atmosphere. Air samples were collected at the site S_1 using commercially available Tenax solid adsorbent (sorbent tube of SKC from SKC Inc., USA) at a flow rate of $0.5\,L\,min^{-1}$ using a constant flow sample pump of SKC over 2-h sampling period early in the morning between 7.00 a.m. and 9.00 a.m. local time to identify the major semi-volatile organic hydrocarbons. Preliminary tests have been conducted to determine the optimum flow rate for the experimental apparatus used to avoid sample breakthrough in the second bed of the tube.

As for the MAH collection, air samples were collected at the three sites using activated charcoal sorbent tubes (150 mg) of SKC at a $1\,L\,min^{-1}$ flow rate. A total of 49 samples were collected at a height of 3 m above the ground level during dry days with calm winds at a frequency of one sample per site and per day for a period of 4–6 h between 7 a.m. and 4 p.m. local time. In a second campaign, 35 samples were collected during winter (November–December 97, January–March 98) and summer (May–August) 1998 at roadside site S_1, while at the other two sites S_2 and S_3, 14 samples were collected during August 1998.

4. Conclusion

Analysis of ambient air samples at three sites in Algiers city reveals the presence of 47 semi-volatile compounds C_6–C_{16} with a large number of aromatic species. The BTEX concentration levels in ambient air are mainly influenced by the road traffic. At roadside, the benzene and toluene average concentrations are 27 and $39\,\mu g\,m^{-3}$, respectively. The BTEX average concentrations are generally two to three times higher than those measured in urban background area. The benzene to toluene and (*m*–*p*) xylene to ethylbenzene ratios mainly reflect the emission of road traffic. The benzene concentration level is in the same order of magnitude than that found in other urban areas around the world. Compared to some US and European cities, Algiers shows serious problems of air pollution particularly in high traffic areas where the benzene regulatory limit value of $10\,\mu g\,m^{-3}$ is largely exceeded. The population staying or living in urban area may be highly affected by air pollutants released through car exhaust emissions. A strong reduction of air pollutant emission from road traffic seems to be necessary which can be partially achieved through better vehicle control and maintenance and by mandating the use of catalytic converters in all vehicles, and the use of cleaner fuels as natural gas and Liquefied Propane Gas (LPG). As BTEX compounds are major pollutants from vehicle exhaust, there is the necessity to tighten automobile emission standards in Algeria. It is also important to expand the present air quality monitoring network for better air pollution measurements which will help develop better control and allow epidemiological studies to assess the impact of air pollution on the population in the Greater Algiers.