Science of the Total Environment 497–498 (2014) 123–132

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Degradation in urban air quality from construction activity and increased traffic arising from a road widening scheme

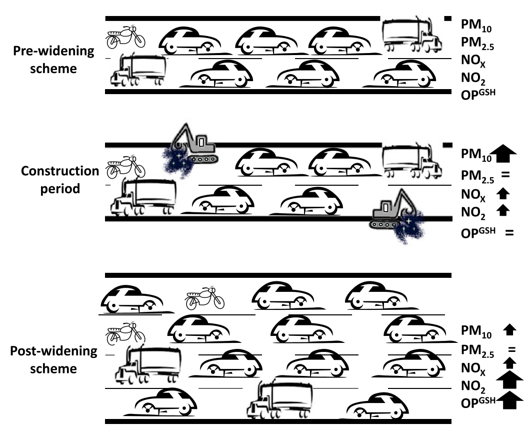
Anna Font *, Timothy Baker, Ian S. Mudway, Esme Purdie, Christina Dunster, Gary W. Fuller

MRC PHE Centre for Environment and Health, King's College London, 150 Stamford Street, London SE1 9NH, United Kingdom

HIGHLIGHTS

- Local air quality deteriorated after completion of a road widening scheme in south London.
- The EU PM_{10} limit value (LV) was breached during construction.
- NO_2 LV was breached after scheme due to increased cars, taxis and LGVs.
- Increase of pro-oxidant components in the PM coarse mode after the road widening.
- Mean PM_{10} emission factor for the construction phase was 0.0022 kg m^{-2} $month^{-1}$.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 28 March 2014
Received in revised form 27 June 2014
Accepted 16 July 2014
Available online xxxx

Editor: P. Kassomenos

Keywords:
Induced traffic
Road widening schemes
Air quality impacts
Source apportionment
Construction PM_{10} emission factor
Oxidative potential

ABSTRACT

Road widening schemes in urban areas are often proposed as a solution to traffic congestion and as a means of stimulating economic growth. There is however clear evidence that new or expanded roads rapidly fill with either displaced or induced traffic, offsetting any short-term gains in eased traffic flows. What has not been addressed in any great detail is the impact of such schemes on air quality, with modelled impact predictions seldom validated by measurements after the expansion of road capacity. In this study we made use of a road widening project in London to investigate the impact on ambient air quality (particulate matter, NO_X, NO_2) during and after the completion of the road works.

PM_{10} increased during the construction period up to 15 μg m^{-3} during working hours compared to concentrations before the road works. A box modelling approach was used to determine a median emission factor of 0.0022 kg PM_{10} m^{-2} $month^{-1}$, three times larger than that used in the UK emission inventory (0.0007 kg PM_{10} m^{-2} $month^{-1}$). Peaks of activity released 0.0130 kg PM_{10} m^{-2} $month^{-1}$, three and eight times smaller than the peak values used in the European and US inventories. After the completion of the widening there was an increase in all pollutants from the road during rush hour: 2–4 μg m^{-3} for PM_{10}; 1 μg m^{-3} for $PM_{2.5}$; 40 and 8 μg m^{-3} for NO_X and NO_2, respectively. NO_2 EU Limit Value was breached after the road development illustrating a notable deterioration in residential air quality. Additionally, PM_{10}, but not $PM_{2.5}$, glutathione dependent oxidative potential increased after the road was widened consistent with an increase in pro-oxidant components in the coarse particle mode, related to vehicle abrasion

* Corresponding author. Tel.: +44 20 7484 4018.
E-mail address: anna.font_font@kcl.ac.uk (A. Font).

http://dx.doi.org/10.1016/j.scitotenv.2014.07.060

processes. These increased air pollution indices were associated with an increase in the number of cars, taxis and LGVs.

1. Introduction

A large number of studies have shown excess health risks from living in close proximity to roads; however their attribution to single air pollutant is less clear. The adverse health effects from road proximity might be due to tailpipe emissions of airborne particles, particles from non-exhaust sources such as tyre and brake wear or gaseous pollutants including NO_2 (WHO, World Health Organization, 2013).

New or widened roads are often proposed to relieve congestion or to support economic growth, however there is a little appraisal of road schemes once they are built (Matson et al., 2006). It has been shown through case studies in the UK and the Netherlands that the benefits from reduced congestion and shorter journey times are often short lived as new road network capacity is taken up by induced traffic growth (Matson et al., 2006). Few studies have considered the air quality impacts of new road construction and its subsequent operation. The available studies are limited to the construction of urban road tunnels (Bartonova et al., 1999; Cowie et al., 2012) and are thus not directly applicable to most urban road schemes; and a scheme in Antwerp designed to reduce road capacity rather than increase it (Stranger et al., 2008).

There is ample evidence that construction activities are an important source of particulate matter (PM) into the atmosphere and can have a substantial temporary impact on air quality. Construction activities represented 3.8% of total particulate emissions from open sources in the US in 1976 (Evans and Cooper, 1980). Dust and other air pollution from demolition and construction can impact greatly on the health and quality of life of people working on and living close nearby with some studies reporting an increment of mortality due to chronic obstructive pulmonary disease among construction workers (Bergdahl et al., 2004). Emissions of PM during the construction of a building or road are associated with land clearing, ground excavation, cut and fill operations and the construction of a particular facility itself. PM emissions from construction are largely in the coarse fraction but they are also a source of airborne ultrafine particles (Kumar et al., 2012). Dust emissions often vary substantially from day to day depending on the level of activity, the specific operations and the prevailing meteorological conditions making it difficult to assess the total contribution of such emissions to the air pollution levels of a city or region (Chang et al., 1999).

Fugitive emissions from construction are generally poorly quantified in global and national emission estimates as most countries do not report fugitive emissions from construction; and the emission factors (EF) for construction activities are uncertain (Janssens-Maenhout et al., 2012). The Environmental Protection Agency (EPA) in the United States (US) and the Coordinated European Particulate Matter Emission Inventory Program (CEPMEIP) in Europe provide EF for construction activities to generate national primary PM emissions. These EFs express the amount of PM_{10} emitted by area disturbed per month of activity and therefore the quantity of PM produced is not dependent on the type of construction but merely on the area of land disturbed. The EPA also lists operation-specific emission factors for use when detailed information (material, silt content, vehicle weight, speed, etc.) is available (EPA, 1995; 2011).

According to the London Atmospheric Emissions Inventory (LAEI), construction and demolition activities are estimated to account for 1.4% of the total PM_{10} emitted in London in 2010 (LAEI, 2013). Examination of PM_{10} measurements across London suggested that fugitive emissions from construction works were responsible for daily mean concentrations above 50 μg m^{-3} at 25% of the monitoring sites for each year during 1999–2001 (Fuller and Green, 2004). Construction activities around King's Cross in London were responsible for the excess levels of PM_{coarse} (particulate matter in the size range 10 μm–2.5 μm) in 2003–2004 (Haynes and Savage, 2007).

This study aimed to quantify the impact on the pollution levels for PM_{10}, $PM_{2.5}$, NO_X and NO_2 arising from extensive road works to redevelop the A206, Thames Road, in south-east London, as a dual carriageway. The road improvements involved a 1.8 km section of the A206 Thames Road and were designed to reduce delays on the route and regenerate the area, the second-largest industrial area in London (Bexley, 2002). The road is located close to the river Thames which is reflected in the gravels and alluvium soil types in the area. It was estimated that around 25,000 m^3 of material would be brought in to construct the road and around 18,000 m^3 would be excavated.

The pre-scheme environmental impact assessment included both traffic and dispersion modelling (EPA CAL3QHC) for the widened road. It predicted an increase of the traffic flow of 19% in the morning peak and 9% in the evening peak but only “marginal” changes in local air quality. Under typical meteorological conditions changes in annual mean concentrations were expected to be −0.2 to +0.1 μg m^{-3} for PM_{10} and −0.8 to +1.8 μg m^{-3} for NO_2 depending on the location (Babtie-Bexley, 2001). The air pollution impact of the construction phase was not considered in the pre-scheme impact assessment.

The construction works lasted for one year and seven months, between January 2006 and August 2007. To quantify the increment of air pollutant concentrations from the road widening scheme a unique pairing of air quality monitoring sites was placed in each side of the road in the centre of the construction area. A source apportionment method was applied to distinguish PM_{10} emitted by road traffic from that emitted by the construction activity and a dedicated fugitive construction PM_{10} EF was calculated and compared with those commonly used in emission inventories.

Air pollution for the time periods before and after the redevelopment works was also analysed to assess any air pollution changes arising from the widened road.

2. Material and methods

2.1. Site location and instrumentation

The road works in the study area lasted for one year and seven months, from January 2006 to August 2007. In order to evaluate the impact on the air quality before, during and after the widening works, two periods of one year and seven months before and after the road works are also analysed. The period “before” was taken from May 2004 until December 2005; the “after” period ran from September 2007 to April 2008.

Air quality monitoring station (AQMS) were located on the north (51.4572°N, 0.1953°E) (AQMS-N) and south sides (51.4569°N, 0.1946°E) (AQMS-S) of the A206 Thames Road, in south-east London, separated by a distance of 58 m. The layout of the road runs from north-west to south-east. Two lateral access roads run from north-east (NE) to south-west (SW) close to AQMS-N; and from W to E close to AQMS-S. During the construction period the access road next to the AQMS-N was unpaved. A mix of one and two storey industrial premises was located east of AQMS-N and a two storey residential housing area was located west of AQMS-S. The suburban background concentration was taken from the measurements at Bexley — Slade Green (51.466°N; 0.1848°E) (AQMS-back) located 1.2 km north-west of AQMS-S and AQMS-N.