What you need to know: air pollution

Short- and long-term effects of air pollutants on human health and their implications for traffic-related morbidity

Introduction: air pollution in Cambridge

Especially within urban and industrialised areas, air quality can deteriorate to an extent where it becomes damaging to human health. In the UK, traffic is the major source of harmful air pollutants[i], such as particulate matter (PM) and nitric oxides (NO_x) including NO_2.

In the city of Cambridge, air quality is monitored by local authorities using stationary sensors: five sensors provide continuous monitoring of multiple pollutants, and 65 diffusion are installed across the city to measure NO_2 average exposure. Though PM levels are below legal levels, as measured at the two measuring sites (Gonville Place and Newmarket Road), NO_2 levels are not[ii].

Particulate matter

The term 'particulate matter' refers to a broad class of pollutants consisting of small, respirable particles of varying composition and origin[iii]. They have a carbon core, but can absorb other pollutants, including metals and carcinogenic compounds[iii].

PM is the air pollutant most reliably associated with human disease, especially of the cardiovascular and respiratory systems[iv]. There is no evidence of a threshold PM exposure below which no adverse health effects occur: all-cause daily mortality is estimated to increase by 0.2–0.6% per 10 $\mu g/m^3$ of PM10[v]. These effects are not limited to vulnerable populations such as the critically ill, but most often affects active individuals with one or more risk factors[iv]. Importantly, combustion-related PM is thought to be the most hazardous[v]. Therefore, though PM levels in Cambridge do not exceed legal limits, it is worthwhile to aim for their further reduction, especially in areas where levels may be higher.

NO_2

NO_2 is formed in combustion engines from NO, which is in turn derived from the nitrogen bound in the fuel itself[vi]. As a relatively large fraction of NO_2 pollution is due to traffic, the spatial distribution of NO_2 varies more than that of other pollutants, meaning measurement of personal exposure is of especial interest[vii].

Laboratory studies have shown inhalation of NO_2 causes irritation deep within the respiratory tract, where it is absorbed with no further systemic effects. Adverse effects of short-term exposure (acute toxicity) begin to occur at concentrations between 0.1 ppm and 2 ppm, but statistically significant long-term effects of workplace exposure have not been demonstrated even in several large cohort studies on miners[viii]. However, on-road ambient air levels of NO_2 have been estimated not to exceed 0.1 ppm in two studies in the United States[ix,x].

From the above, it is unclear whether the NO_2 exposure experienced by cyclists in Cambridge traffic is likely to be harmful to health. Evidence of adverse effects of both short-term and long-term exposure to NO_2 is considered to be strengthening by the UK government, in part based on laboratory studies; however, as the levels of NO_2 correlate

with those of other traffic-emitted pollutants, the correlation between higher NO_2 levels and cardiovascular and respiratory morbidity cannot currently be taken for causation[xi].

Low-end pollutant sensors

The CamBike Sensor project aims to use cheap sensors to measure the levels of specific air pollutants on the roads of Cambridge, so that many citizens will be able to participate. Low-end NO_2 and PM10 sensors have been tested for this purpose. In the comparison of the two sensor types, the PM10 sensors performed better.

The NO_2 sensors tested were metal oxide NO_2 gas sensors (type MiCS-2714). These sensors are very small, which is favourable for incorporation into a sensor hub, but are also challenging to incorporate due to the soldering required. Additional disadvantages were their limit of detection that was close to 0.1 ppm, and an unspecified response time of potentially half a minute. These specifications are not fit for purpose, since, as outlined above, expected exposures will likely fall below these limits, and since a cyclist can cover significant distances within half a minute, over which pollution levels are unlikely to be constant.

The tested PM sensors were dynamic light scattering-based devices set up to measure PM10 (and PM2.5) (type SDS011). The PM10 sensors were larger, and consumed a significant amount of power, but comparison of output values to reference sensors within Cambridge indicated they are fairly accurate and therefore could potentially be used for network calibration or averaging.

Conclusion: implications for CamBike Sensor

It is recommended that the CamBike Sensor hub will incorporate a particulate matter sensor to measure air quality, rather than an NO_2 sensor, for several reasons:

- fewer PM10 sensors than NO_2 sensors currently operate in Cambridge;
- the evidence for the adverse health effects of air pollution is stronger for particulate matter than for NO_2;
- the performance of available low-end sensors is better for PM10 than NO_2 measurement.

References

[i] Department for Environment Food & Rural Affairs. Causes of air pollution. Retrieved from: https://uk-air.defra.gov.uk/air-pollution/causes.

[ii] Lewis, A., & Bruce, E. (2017). 2017 Air Quality Annual Status Report. Cambridge, United Kingdom: Cambridge City Council. Retrieved from: https://www.cambridge.gov.uk/sites/default/files/air-quality-annual-status-report-2017.pdf.

[iii] Kampa, M., & Castanas, E. (2008). Human health effects of air pollution. *Environmental pollution*, *151*(2), 362-367.

[iv] Anderson, J. O., Thundiyil, J. G., & Stolbach, A. (2012). Clearing the air: a review of the effects of particulate matter air pollution on human health. *Journal of Medical Toxicology*, *8*(2), 166-175.

[v] Joint WHO/Convention Task Force on Health Aspects of Air Pollution according to the Memorandum of Understanding between the United Nations Economic Commission for Europe and the WHO Regional Office for Europe (2013). Health effects of particulate matter: policy implications for countries in eastern Europe, Caucasus and central Asia. Copenhagen, Denmark: WHO Regional Office for Europe. Retrieved from: http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf

[vi] Vovelle, C. (Ed.). (2013). Pollutants from combustion: formation and impact on atmospheric chemistry (Vol. 547). Springer Science & Business Media.

[vii] WHO Regional Office for Europe (2013). Review of evidence on health aspects of air pollution – REVIHAAP Project: Technical Report (C, Proximity to roads, NO2, other air pollutants and their mixtures). Copenhagen, Denmark: WHO Regional Office for Europe. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK361807/

[viii] European Commission (2014). Recommendation from the Scientific Committee on Occupational Exposure Limits for Nitrogen Dioxide. Brussels, Belgium: Scientific Committee on Occupational Exposure Limits (SCOEL). Retrieved from ec.europa.eu/social/BlobServlet?docId=3803&langId=en.

[ix] Richmond-Bryant, J., Owen, R. C., Graham, S., Snyder, M., McDow, S., Oakes, M., & Kimbrough, S. (2017). Estimation of on-road NO 2 concentrations, NO 2/NO X ratios, and related roadway gradients from near-road monitoring data. A*ir Quality, Atmosphere & Health*, 10(5), 611-625.

[x] Shaibal, M., Luther, S., Halley, B., Casson, S., Lucas, N., Sue, K., & Ronald, W. (2015). Comparison of modeled traffic exposure zones using on–road air pollution measurements. *Atmospheric Pollution Research*, 6(1), 82-87.

[xi] Committee on the Medical Effects of Air Pollutants (2015). Statement on the evidence for the effects of nitrogen dioxide on health. Chilton, Oxfordshite, United Kingdom. Retrieved from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/411756/COMEAP_The_evidence_for_the_effects_of_nitrogen_dioxide.pdf.