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COMEAP/2018/04 WORKING PAPER 6

COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

A viewpoint on the comparison of published health-based exposure limits (occupational and population) with PM concentrations in the London Underground

1. This paper prepared by Dr Sarah Robertson and Miss Kerry Foxall compares published health-based exposure limits (occupational and population) with particulate matter (PM) concentrations in the London Underground

2. Note: This is a draft working paper for discussion. It does not reflect the final view of the Committee and should not be cited.

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1 Metal concentrations in PM were available from measurements performed in one station of the London Underground. Smith et al. (2018)[1] collected $PM_{2.5}$ filter samples every 4 hours over a period of 48 hours from Hampstead underground station in November 2017, the deepest station below street level on the London Underground (58.5 m). It is therefore likely that PM from Hampstead station represents a relatively "pure" underground PM, with little contribution from outside sources. Of the metals measured, we considered several to be potentially relevant to health: chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), vanadium (V), arsenic (As), cadmium (Cd), cobalt (Co) and zinc (Zn). The COMEAP Sub-group drew on published health-based assessments (e.g. workplace exposure limits (WELs), World Health Organization (WHO) Air Quality Guidelines (AQG), EU Target Values, recommendations from the Expert Panel on Air Quality Standards (EPAQS) etc.) in order to assess whether the reported concentrations of these metals in the London Underground samples were of public health concern.

2 Metal concentrations in the $PM_{2.5}$ samples collected from Hampstead underground station were all several orders of magnitude below the current UK Health and Safety Executive WELs[2] (see Table 1).

3 For comparison with concentrations in air that are considered tolerable for the general public, the COMEAP Sub-group made a number of adjustments to the measured concentrations. To account for the fact that the measurements in the London Underground were of concentrations in the $PM_{2.5}$ fraction, while many of the health-based recommendations are for metal concentrations in the PM_{10} fraction, the measured London Underground $PM_{2.5}$ samples were converted to concentrations in the PM_{10} fraction using an approximate conversion factor of 2 (based on a study by Gustafsson et al. (2006) that found the $PM_{2.5}$ proportion in the Stockholm underground railway to be approximately 50% of PM_{10})[3]. After this conversion, it was also necessary to take into account that health-based guidance values for the general population are derived to be protective over continuous lifetime exposure, while users of the London Underground would only be exposed for a short time, during their journey. According to the London Travel Demand Survey[4], across all 7 days of the week, the average daily commuting time for adults (aged 30-59 years)

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[1] J.D. Smith, B. Saunders, D. C. Green, M. Priestman, A. H. Tremper, I. Mudway, G. W. Fuller, E. Nicolosi, T. Smith and B. M. Barratt (2018). Public health risks from respirable particles on the 'London Underground' metro network; should we be concerned? (In Press)

[2] http://www.hse.gov.uk/pubns/books/eh40.htm

[3] This factor is numerically consistent with the method used by WHO to convert guidelines in ambient air for PM_{10} to $PM_{2.5}$ by application of a $PM_{10}/PM_{2.5}$ ratio of 0.5 (WHO Air Quality Guideline 2005)

[4] See https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/consultations-and-surveys/london-travel-demand-survey and Table 1 in Working Paper 5

who use the London Underground is 60 minutes (sum of platform wait time, time spent in carriage and moving time between platforms). Hence, we used 1 hour and divided the subway PM_{10} concentrations by 24 to convert the 24-hour average concentrations to 1-hour average concentrations. .

4 Table 1 shows the comparisons between concentrations of metals in PM measured at Hampstead underground station and at the London Marylebone Road measurement station with health-based exposure limits. The levels of As, Fe, Mn and Ni were not of toxicological concern for the general population. However, given the uncertainties and the range of sampling and analysis, more data are needed to obtain better estimates of any potential risk that these metals pose to public health. Adjusted total Cr concentrations (using the assumptions set out above) were much higher than the available guidance value, which is for hexavalent Cr (Cr (VI)), the most toxic form of the element. They were also much higher than the concentrations of total Cr in ambient air. However, there is insufficient information on total Cr levels in Underground air to estimate the potential risk from this metal, though it is important to note that very little of the total Cr concentration would need to be in the form of Cr (VI) to pose a potential risk to health. It will be important that future measurements confirm both the concentrations and oxidative state of Cr present in Underground air.

Table 1: Concentrations of metals measured at Hampstead underground station and at the London Marylebone Road measurement station with health-based exposure limit values

	Population health-based exposure limit values (annual mean unless stated)				$PM_{2.5}$ concentrations (ng/m^3) collected from Hampstead underground station				
Metal	**EP AQS (2009)[5]**	**WHO AQG (2000)[6]**	**WHO IPCS tolerable concentration[7]**	**EU target values[8]**	**24 h mean concentration (ng/m^3)**	**Day-time mean concentration (8:00 – 20:00 h) (ng/m^3)**	**Converted Hampstead tube PM_{10} concentration (ng/m_3)****	**HSE WEL long-term (8 h; based on inhalable dust fraction)[2]**	**London Marylebone Road annual mean; PM_{10} fraction (ng/m^3)**
Arsenic (As)	3 ng/m^3 inorganic As in PM_{10} fraction	6.6 ng/m^3 in PM_{10} fraction		6.6 ng/m^3 in PM_{10} fraction	13.07	15	1.25	0.1 mg/m^3 (10000 ng/m^3)	1.12
Cadmium (Cd)	5 ng/m^3 in PM_{10} fraction	5 ng/m^3 in PM_{10} fraction		5 ng/m^3 in PM_{10} fraction	3	4	0.33	0.025 mg/m^3 (2500 ng/m^3)	0.17
Cobalt (Co)			100 ng/m^3 in PM_{10} fraction		14.71	19	1.58	0.1 mg/m^3 (10000 ng/m^3)	0.21
Total Chromium (Cr)	0.2 ng/m^3 (Cr(VI))	0.25 ng/m^3 (Cr(VI))			780.43	973	81.08	0.05 mg/m^3 (5000 ng/m^3)	8.91

[5] http://webarchive.nationalarchives.gov.uk/20130403213731/http://archive.defra.gov.uk/environment/quality/air/airquality/panels/aqs/documents/metals-and-metalloids.pdf
[6] http://apps.who.int/iris/bitstream/handle/10665/107335/E71922.pdf;jsessionid=3196FB686B82507262C6201DD0C0B1D2?sequence=1
[7] WHO International Programme on Chemical Safety (IPCS): http://www.who.int/ipcs/assessment/en/
[8] http://ec.europa.eu/environment/air/quality/standards.htm

	in PM_{10} fraction	in PM_{10} fraction							
Copper (Cu)					143.21	190	15.83	1 mg/m^3 (100000 ng/m^3)	53.98
Iron (Fe)					183646 (0.18 mg/m^3)	240432 (0.24 mg/m^3)	20036 (0.2 mg/m^3)	1 mg/m^3 (100000 ng/m^3)	1544
Manganese (Mn)					2233	2927	243.92	0.5 mg/m^3 (note this is 15 min as no 8 h data; 50000 ng/m^3)	14.06
Nickel (Ni)	20 ng/m^3 in PM_{10} fraction	25 ng/m^3 in PM_{10} fraction		5 ng/m^3 in PM_{10} fraction	77.36	99	8.25	0.1 mg/m^3 (10000 ng/m^3)	1.78
Vanadium (V)			1 µg/m^3 in PM_{10} fraction (24 h mean)		18.86	25	2.08		1.01
Zinc (Zn)					469.43	757	63.08	10 mg/m^3 (1000000 ng/m^3)	33.59

* Calculated by multiplying the average daytime Hampstead $PM_{2.5}$ concentrations by 2 and then dividing by 24 to take into account the average daily commuting time for adults (aged 30-59 years) who use the London Underground is 60 minutes