an nsca publication

LEVELS OF CARBON MONOXIDE EXPERIENCED CYCLING IN CENTRAL LONDON

by

Mark Pyman*

Reprinted from *Clean Air*, Vol. 11, Number 1, 1981

Clean Air is the official journal of the National Society for Clean Air

* Dr. M.A.F. Pyman, 7 Erpingham Road, London SW15.

INTRODUCTION

When discussing with London commuters the merits of cycling to and from work, the most common reason given for preferring other forms of transport to and from work was that the levels of noxious fumes on the road were thought to be so great that exposure to such fumes whilst cycling would result in damage to health. This study was initiated when the author found that whilst there was plenty of published work on the exposure of car drivers to noxious fumes (particularly CO, SO_2, NO_x, Pb and O_3) and on the levels experienced at fixed monitoring stations, there was very little known about what a cyclist is actually exposed to.

It was decided to use carbon monoxide (CO) as a guide to the level of noxious fumes experienced, and to measure the exposure of a cyclist to carbon monoxide on a regular route into and out of central London during the rush hour period.

METHOD

A continuous carbon monoxide analyser (Ecolyser type, model 2100) was used in conjunction with a data memory (Phillip Harris Ltd), the stored data being written out to a strip chart recorder at the end of the journey. The input to the analyser was through a 3" diameter filter funnel mounted at head height at the front of the bicycle, and ¼" internal diameter polythene tubing and a millipore filter. The analyser and data-logger were mounted in a case placed on the rear carrier of the cycle (a Raleigh RSW 16), the whole arrangement being as shown in Figs 1 and 2. Normally the analyser output (range 0-100 ppm) was logged at 300 readings per hour and replayed at 30 readings per minute onto a chart moving at ½ mm per second.

The analyser was calibrated using carbon monoxide calibrating gas (53 ± 1 ppm) immediately before the journey to work, on arrival at work, and immediately after returning from work in the evening. The analyser was zeroed before each journey to work.

The route taken was always the same, starting from West Hammersmith, W6, and finishing in Buckingham Palace Road, SW1.

The route was in three sections. In to work: W. Hammersmith along King Street, Hammersmith Broadway, Hammersmith Road and Earls Court Road to the Cromwell Road (2.6 miles): Cromwell Road (1.3 miles), and then to Buckingham Palace Road via Pont Street and Lyall Street (1.0 miles).

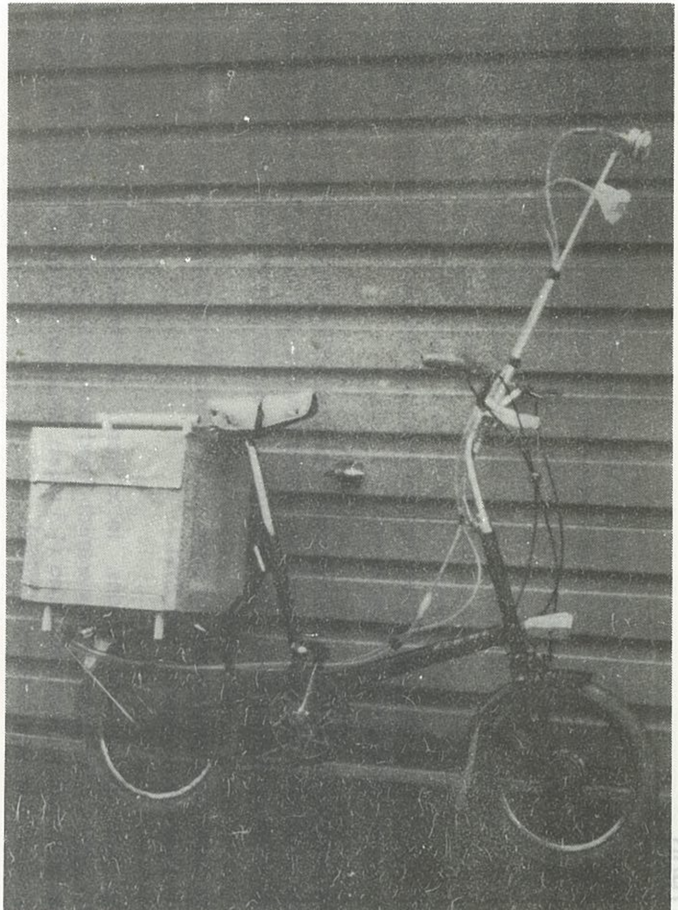

Fig 1 The test bicycle

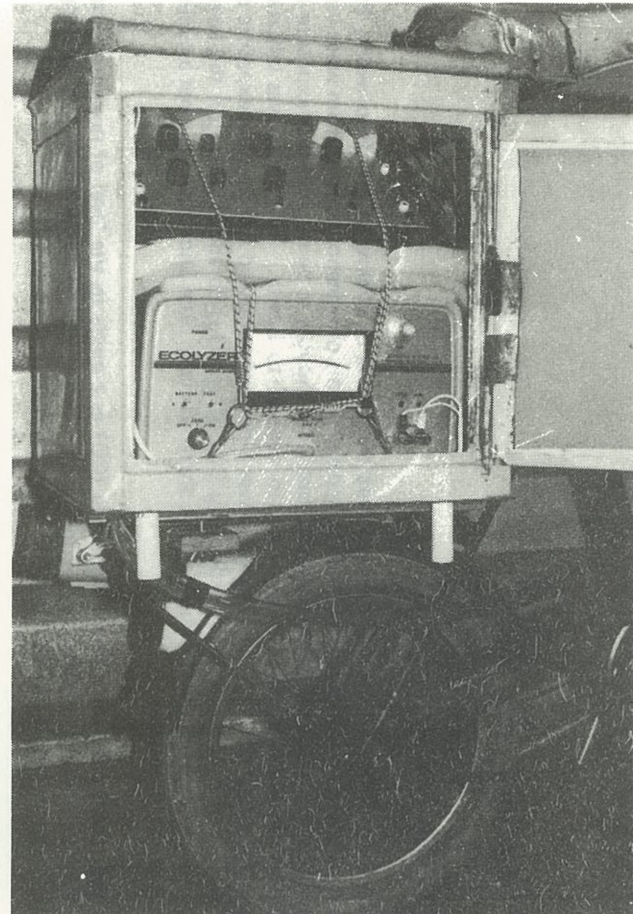

Fig 2 Ecolyser and datalogger in case

On the return journey: Buckingham Palace Road to the Cromwell Road via Sloane Square (1.3 miles); Cromwell Road to Hammersmith Broadway (2.7 miles) and Hammersmith Broadway to Ravenscourt Park (0.9 miles); in both cases a journey of five miles, taking about 30 minutes.

The mean hourly traffic flow between 0700 and 1000 and 1600-1900 (in brackets), estimated from observed mean hourly flows between 1000 and 1600, are as follows for the relevant roads: King Street 1000 (2100), Hammersmith Broadway 5300 (3300), Hammersmith Road 2700 (2600), Cromwell Road 6100 (5900), Pont Street 2400 (2400), Buckingham Palace Road 900 (1100).

The weather conditions (winds, rain, dust, temperature) were noted qualitatively for each journey.

RESULTS

Preliminary experiments were carried out over a period of two weeks to test the performance of the analyser under normal cycling conditions, in order to check that the frequent changes in speed and direction that occur on a cycle did not give rise to spurious peaks of increased background noise relative to a stationary instrument.

To test this possibility, a large reservoir of air with a low carbon monoxide content (exhaled air) was connected to the analyser input to form a closed system and the journey then carried out as if for an ordinary run. This experiment was repeated several times, and the results compared to a control in which the apparatus was largely stationary and partly carried about by hand.

A typical result is shown in Figure 3 with the control shown in Figure 4. It can be seen that whilst the effect of being carried on a moving bicycle does increase the background noise level, the loss in precision is sufficiently small that fluctuating CO levels in a normal traffic environment would be expected to show up satisfactorily.

It was noticeable, however, that the effect of being carried around on a bicycle was to compress the upper range of the response relative to the baseline, as seen by the decreasing levels of the calibrations in Figure 3. This compression, apparent in all the cycle runs, was judged to be unavoidable and allowance made for it in the presentation of the results.

Results from four actual runs are shown graphically in Figures 5-8, where a 'run' consists of both the journey to work and the return journey.

The runs were carried out over a total period of three months from April 1980 – June 1980. The four shown in Figures 5-8 are typical of all the results.

The results showed no observable correlation with wind, rain, dust or temperature conditions, but were clearly directly related to traffic density. In addition, higher carbon monoxide levels were experienced after the evening rush hour than before the morning rush hour.

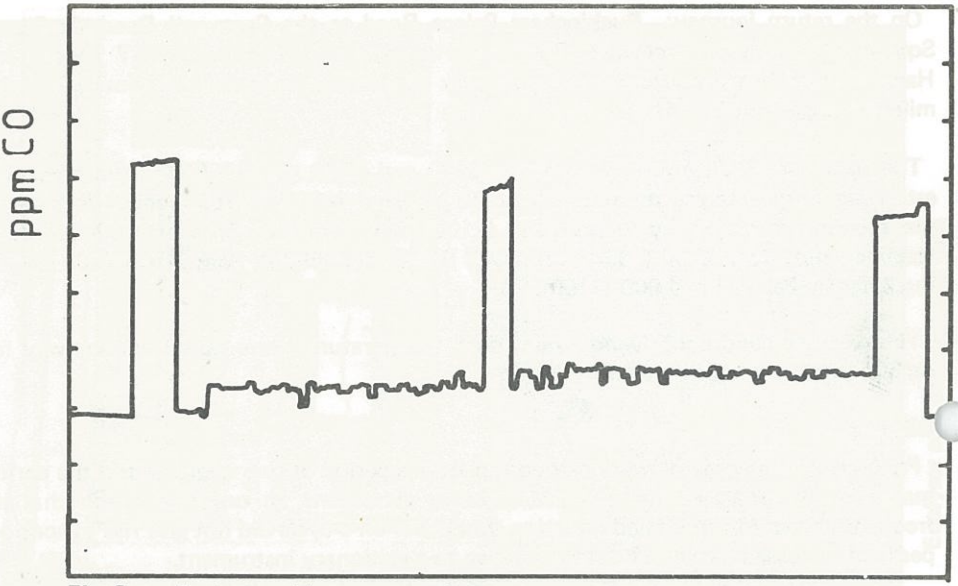

Fig 3 Test run with constant CO input

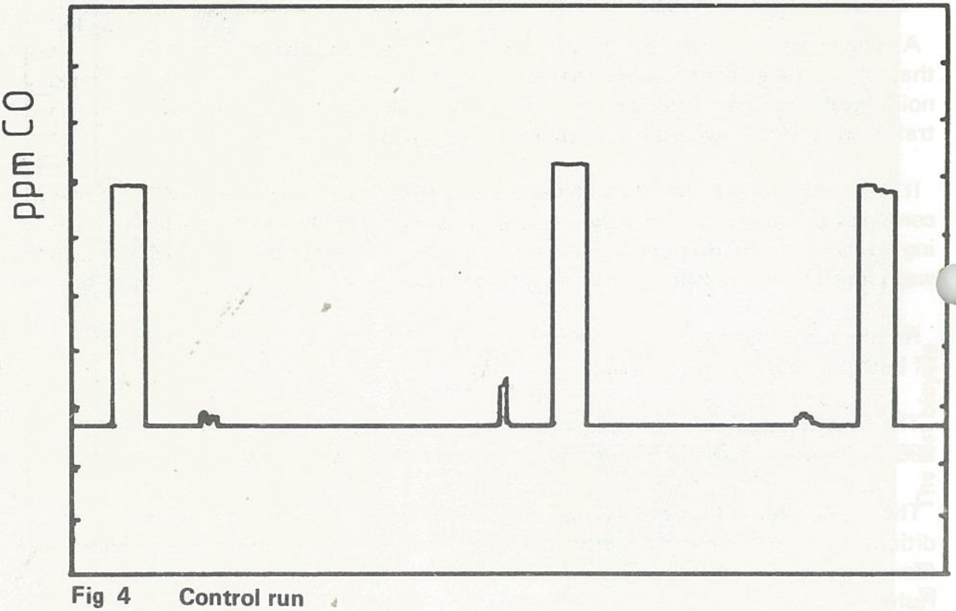

Fig 4 Control run

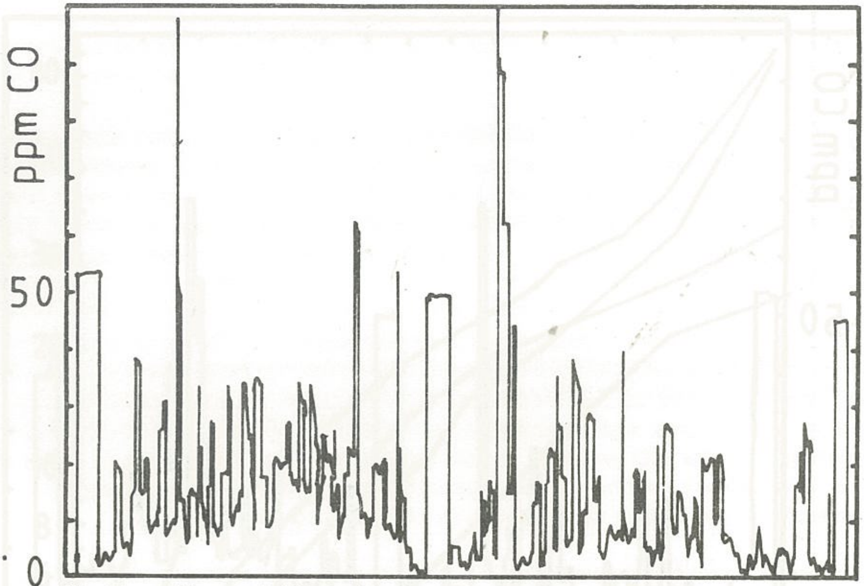

Fig 5 IN : 8.30am Mean = 21 ppm SD = 13 ppm
OUT : 6.00pm Mean = 15 ppm SD = 13 ppm

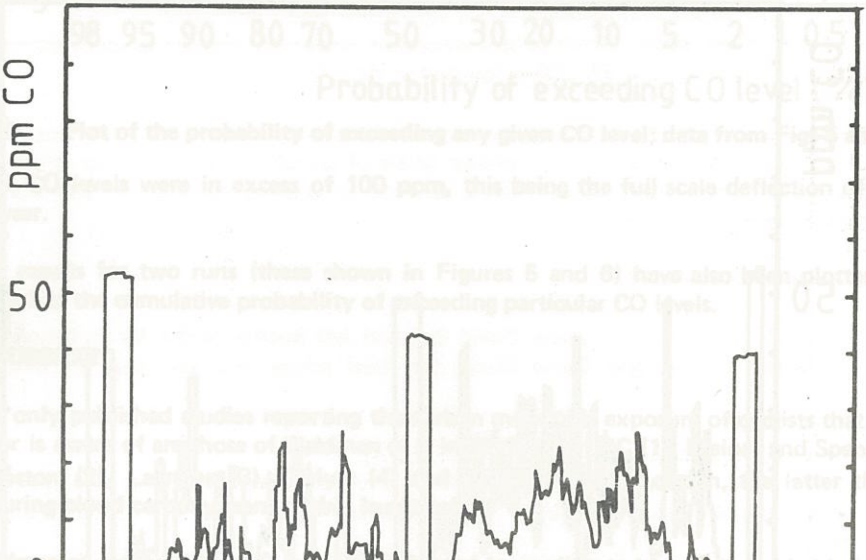

Fig 6 IN : 7.45am Mean = 7.5 ppm SD = 6 ppm
OUT : 7.00pm Mean = 14 ppm SD = 6 ppm

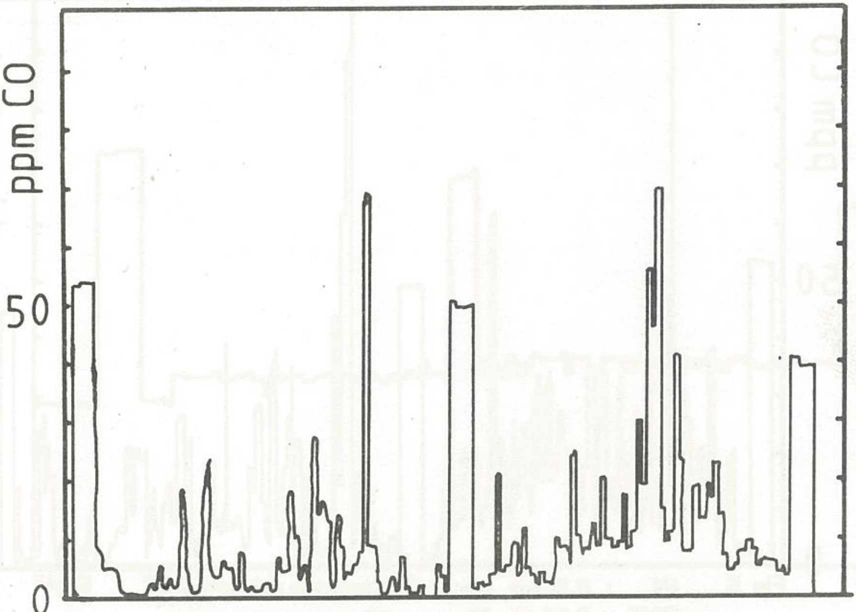

Fig 7 IN : 7.00am Mean = 8.5 ppm SD = 16 ppm
OUT : 7.00pm Mean = 15 ppm SD = 14 ppm

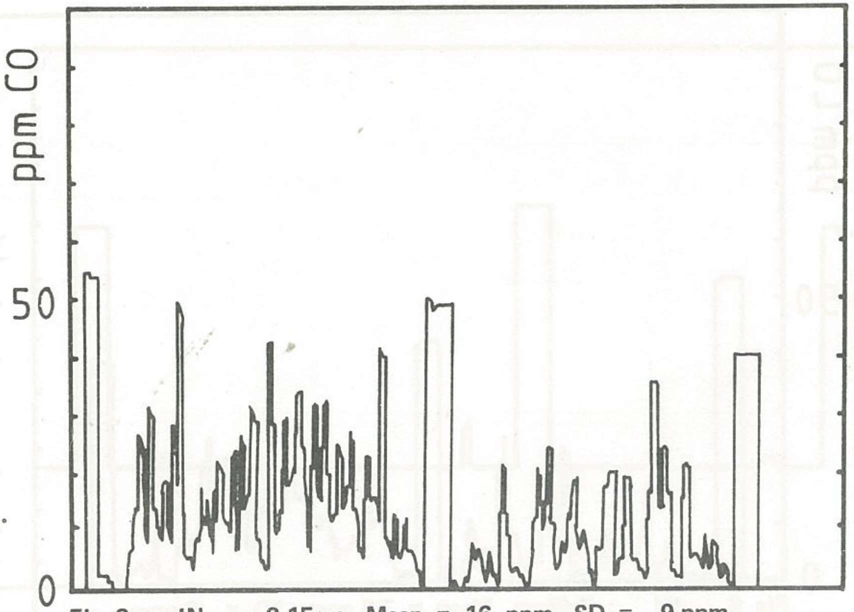

Fig 8 IN : 8.15am Mean = 16 ppm SD = 9 ppm
OUT : 7.00pm Mean = 11 ppm SD = 7 ppm

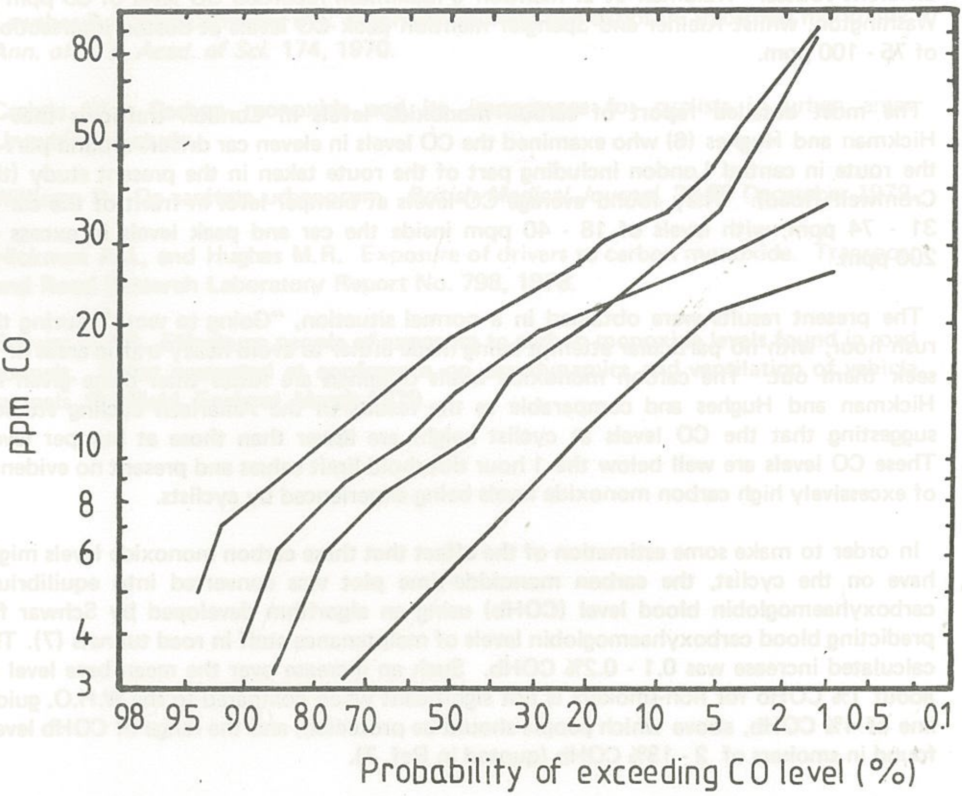

Fig 9 Plot of the probability of exceeding any given CO level; data from Figs 5 and 6.

Peak CO levels were in excess of 100 ppm, this being the full scale deflection of the Ecolyser.

The results for two runs (these shown in Figures 5 and 6) have also been plotted in Figure 9 as the cumulative probability of exceeding particular CO levels.

DISCUSSION

The only published studies reporting the carbon monoxide exposure of cyclists that the author is aware of are those of Waldman et al in Washington DC (1), Kleiner and Spengler in Boston (2), Lawther (3), Carlyle (4) and Williams (5) in London, the latter three measuring blood carboxyhaemoglobin levels only.

Waldman et al found the CO levels experienced by cyclists to be indistinguishable from those experienced by car drivers on the same routes, the mean levels being in the range 6.8 - 14.0 ppm for four routes of varying traffic volume and building density. Kleiner and Spengler found mean CO levels exposed to cyclists of 8.8 - 17.3 ppm over three different routes. Waldman et al mention a maximum recorded CO level of 80 ppm in Washington, whilst Kleiner and Spengler mention peak CO levels at Boston intersections of 75 - 100 ppm.

The most detailed report of carbon monoxide levels in London traffic is that of Hickman and Hughes (6) who examined the CO levels in eleven car drivers around part of the route in central London including part of the route taken in the present study (the Cromwell Road). They found average CO levels at bumper level in front of the car of 31 - 74 ppm, with levels of 18 - 40 ppm inside the car and peak levels in excess of 200 ppm.

The present results were obtained in a normal situation, "Going to work" during the rush hour, with no particular attempt being made either to avoid heavy traffic areas or to seek them out. The carbon monoxide levels obtained are lower than those given by Hickman and Hughes and comparable to the results of the American cycling studies, suggesting that the CO levels at cyclist height are lower than those at bumper level. These CO levels are well below the 1 hour threshold limit values and present no evidence of excessively high carbon monoxide levels being experienced by cyclists.

In order to make some estimation of the effect that these carbon monoxide levels might have on the cyclist, the carbon monoxide-time plot was converted into equilibrium carboxyhaemoglobin blood level (COHb) using an algorithm developed by Schwar for predicting blood carboxyhaemoglobin levels of maintenance staff in road tunnels (7). The calculated increase was 0.1 - 0.2% COHb. Such an increase over the mean base level of about 1% COHb for non-smokers is not significant when compared to the W.H.O. guide-line of 4% COHb, above which people should be protected, and the range of COHb levels found in smokers of 2 - 13% COHb (quoted in Ref. 7).

In the context of the original objective of the study, it seems fair to conclude that cyclists are probably exposed to similar levels of carbon monoxide as car drivers. The consequent carboxyhaemoglobin levels are not so large as to result in any significant adverse effect on the cyclist.

ACKNOWLEDGEMENTS

The author would like to thank David Ball and Jeff Booker of the Air Pollution Group, GLC, David Shillito and David Slater for their advice and assistance in this study.

REFERENCES

1. Waldman M., Weiss S., and Articola W. A study of the health effects of bicycling in an urban atmosphere. US Dept. Transportation, Report No. DOT-TES-78-001, Oct. 1977.

2. Kleiner B.C., and Spengler J.D. Carbon monoxide exposure of Boston cyclists. *J. Air Poll. Control Assoc.* **26** (2), 147, 1979.

3. Lawther P.J., and Commins B.T. Cigarette smoking and exposure to carbon monoxide. *Ann. of N.Y. Acad. of Sci.* 174, 1970.

4. Carlyle W. Carbon monoxide and its importance for cyclists in urban areas. Unpublished study.

5. Williams R. De sanitate urbanorum. *British Medical Journal,* 22-29 December 1979.

6. Hickman A.J., and Hughes M.R. Exposure of drivers to carbon monoxide. Transport and Road Research Laboratory Report No. 798, 1978.

7. Schwar M.J.R. Effects on people of exposure to carbon monoxide levels found in road tunnels. Paper presented at conference on aerodynamics and ventilation of vehicle tunnels, Sheffield, England, March 1979.