A PILOT SURVEY INTO THE PROBLEM OF MOTOR VEHICLE AIR POLLUTION IN TRINIDAD

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SUMMARY

Samples of air collected from selected sites which are scenes of heavy traffic conditions, were tested for two pollutants that are constituents of motor vehicle exhausts Carbon Monoxide and Nitrous Oxides.

It was found that the air in one of the selected locations is unsatisfactory by any criterion, and the air in some of the other sites may be close to threshold conditions. Suggestions are made as to long and short-term measures which can be taken to deal with the situation.

INTRODUCTION

The question of air pollution is attracting worldwide attention today. In Trinidad and Tobago, as a developing nation, it may be expected that pollution in its various forms would not be as serious a problem as in an industrialised country. Nevertheless, industrial air pollution from such sources as the Texaco Oil Refinery, Federation Chemicals (Grace), Trinidad Cement Limited and the sugar cane factories, produce tangible, in some cases visible, effects on the environment; this indicates that the problem is definitely with us. While concern has often been expressed about our environment, to date no scientific testing of the ambient air in Trinidad and Tobago has been carried out.

The object of this investigation was to ascertain whether air pollution in Trinidad and Tobago is a cause for serious concern. Due to the limited resources at our disposal the decision had to be taken to concentrate on one aspect of the problem air pollution from motor vehicles.

Figure 1 shows that the motor vehicle is the most serious source of air pollution in the United States, where it contributes 60% of the overall total (5) . In Trinidad and Tobago, which in 1970 had a per capita vehicle population of 1 in 10 (3), and where the problems of traffic congestion are painfully evident, it is reasonable to assume that the motor vehicle is also the most serious source of air pollution.

In addition, it should be borne in mind that most of the industrial air pollution is discharged into the atmosphere at a comparatively high altitude, while motor vehicle pollutants enter the atmosphere at ground level, and are more likely to be present in the "breathing zone".

It was therefore decided that the problem of motor vehicle air pollution should be the target of our investigation.

THE GASEOUS POLLUTANTS

The main pollutants emanating from motor vehicles are carbon monoxide, oxides of nitrogen, hydrocarbons and lead. A WHO monograph(7) dealing with the problem of motor vehicle air pollution gives the following measurements of the concentration of these pollutants in urban air, based on worldwide observation.

Carbon Monoxide · average values in urban air 12-16 parts per million. In heavy traffic may quite easily rise to 20-100 p.p.m., with peak reported values 200-400 p.p.m. Oxides of Nitrogen – usually less than 0.1 p.p.m., but may rise to 1 p.p.m. Highest value reported is 2.29 p.p.m. in Los Angeles.

Hydrocarbons ·· 10-12 p.p.m. reported in heavy traffic in U.S. 40 p.p.m. recorded in Los Angeles.

Lead – 3 μg/m3 in urban and industrial areas. In heavy traffic, may rise to 14-25μg/m3.

Of these pollutants, by far the most serious problem is Carbon Monoxide, which is the only one to occur in concentrations that can constitute a definite health hazard(7).

It was therefore decided that the detection of Carbon Monoxide, would be the primary target of our research. In an investigation of this type, where it was not certain that the problem justified the use of expensive methods, the detection of hycrocarbons had to be ruled out.

SAMPLING METHOD

The "modus operandi" of our research work was as follows:–

A number of locations which, according to our observations, had high traffic densities, was selected. At hours of peak traffic congestion air samples were collected from these points, using 1ft^3 capacity polythene bags for "grab sampling". Subsequently, samples were collected over a continuous 12-hour period from one of these points which had given the highest CO readings.

For each sample a new polythene bag, which had not previously been opened, was used. The bag would be opened on the leeward side of the traffic with its mouth facing the wind direction and held at about face level. If there was no wind a swirling action was used to inflate the bag. The mouth of the bag was then closed and a rubber band was used to seal the neck. Notes were made of the wind, weather and traffic conditions.

The testing of samples was carried out by use of the Drager gas detector and Drager colorimetric tubes. This instrument has a possible error of ± 10%, which was considered adequate for our purposes(9).

To test each sample, a Drager tube was fitted into the gas detector and the open end of the tube was placed against the sealed neck of the bag. A second rubber band was then used to seal the outer neck of the bag around the tube before removing the first rubber band from the neck. This ensured that the tube only received air from inside the bag.

All samples collected were tested for Carbon Monoxide, using either Drager tube No.CH-256 or No. CH-289. In both these tubes, the test is based on the colour reaction of CO with Iodine pentoxide, selenium dioxide and sulphuric acid. Tube CH-256 has scale readings down to 5 parts per million CO, while tube CH-289 gives readings down to 10 p.p.m. CO. Samples which gave CO readings of 50 p.p.m. or greater, were also tested for nitrous oxides, using Drager tube CH-294. This test is based on the colour reaction of NO_2 with dianisidine and a prelayer in each tube oxidises any NO present to NO_2, before testing. Since the lowest reading possible on this tube is 0.5 p.p.m. Nitrous Oxides and the average level in urban air is 0.1 p.p.m., it was felt that no useful purpose would be served by testing every sample for these gases.

The method of "grab sampling" and the use of the Drager gas detector for testing, was felt to be both adequate and suitable for a pilot survey (9).

CHOICE OF SITES

Test samples were collected from 8 sites in all as follows:--

Station 1 Junction of the Churchill-Roosevelt Highway and the Beetham Highway. This point is 2 miles east of the city of Port of Spain and is on a main route for city-bound traffic on mornings. Bumper to bumper traffic stretches from Port of Spain well to the east of this point. There is a tendency for traffic flow to improve west of this point as it enters the Beetham Highway, which is a dual carriageway. The ventilation here is very good, with wide-open space to the southwest.

Station 2 Corner of Frederick Street and Independence Square in Port of Spain. A busy intersection in the heart of the commercial area. Ventilation is fair at this point. Independence Square is very wide, but tall surrounding buildings may inhibit dispersal of fumes.

Station 3 Corner or Frederick and Park Streets in Port of Spain. A confluent point for traffic entering Port of Spain from the North West. Traffic light control. Ventilation poor (two narrow streets).

Station 4 Corner of Independence Square and Wrightson Road, Port of Spain. A considerable volume of traffic bound for the heart of Port of Spain passes through this point on mornings. In addition, traffic from the east of Port of Spain bound for areas to the west of the capital and vice versa, uses Wrightson Road as a "bypass" of Port of Spain, thereby aggravating the traffic problem.

This junction is controlled by a policeman during rush hours. To the south and west of this point lies the wharves area and ventilation is only fair.

Station 5 Corner of Western Main Road and Dengue Street, St. James, Port of Spain. This situation lies on a main route for traffic entering Port of Spain from the west and there is a pushbutton-operated pedestrian crossing at this point. Ventilation appears to be fair.

Station 6 Croisee Junciton, Eastern Main Road, San Juan. Located 3 miles east of Port of Spain.

Station 7 Mt. D'Or Road Junction, Eastern Main Road, Champs Fleurs. Located 4½ miles east of Port of Spain.

Station 8 Curepe Junction, Eastern Main Road, Curepe. Located 6 miles east of Port of Spain.

Stations 6 to 8 present a special problem. They all are on a main traffic artery, the Eastern Main Road. From Port of Spain to Arima, 15 miles to the East, this road with its heavy traffic load, runs almost entirely through built-up areas which have grown on either side of it in ribbon development fashion.

The presence of built-up areas on both sides of a main road inhibits ventilation and under easterly wind conditions the Eastern Main Road would act as a breezeway, tending to cause pollutants to remain in the air along the road.

At Station 6, which is either traffic-light or police controlled, traffic from areas north and south of the Eastern Main Road joins and aggravates the main road traffic Ventilation is fair

Station 7 is identical except that ventilation is better and traffic only enters the main road from the north

At Station 8 the problem is exacerbated because the Southern Main Road meets the Eastern Main Road here and there is also a northbound road leading to the Maracas district. This intersection is a destination point for an appreciable volume of traffic from both Port of Spain and the Southern town of San Fernando. Ventilation is fair.

Stations 1 to 5 were selected at the start of our investigation.

The low readings obtained at Station 5, the only location on the Western side of Port of Spain, suggested that pollution at this point could be considered non-existent, and this site was therefore abandoned.

Stations 6 to 8 were selected after the start of our investigations. to check for pollution levels along the Eastern Main Road.

Readings from Station 8 indicated that it had the highest pollution levels of all, and it was decided to do a special study at this point. On a selected weekday samples were collected at this station at half-hour intervals over a 12-hour period and tested on the spot for Carbon Monoxides and, in two cases, Nitrous Oxides.

DISCUSSION OF RESULTS

Station No.	Average Reading	Highest Reading	Lowest Reading	Number of Tests
1	22.0	50	3	12
2	14.5	25	3	6
3	19.5	34	8	8
4.	43.0	130	12	9
5	8.3	13	2	3
6	36.0	75	7	9
7	52.5	100	5	4
8	70.0	120	25	3

TABLE 1. CARBON MONOXIDE READINGS IN PARTS PER MILLION FOR VARIOUS STATIONS

The CO readings obtained, exclusive of the 12-hour probe at Curepe Junction (Station 8) are summarised in Tables 1 and 2. It should be borne in mind that the values in these tables all represent air pollution levels during peak hour traffic.

Table 1 gives a comparison of the average pollution levels during peak hours at each station, while Table 2 gives some idea of the disparity in results obtained each day.

In any given day's testing, one or two samples of air were taken at each site visited that day. For instance, it may be noted from Table 2 that on November 14, a low reading of 10 p.p.m. was obtained on both Station 6 samples.

Date	Total No. of Tests	Highest (Station)	2nd Highest (Station)	Lowest (Station)	Stations visited
31/10/72	9	45(4)	30(1)	10(2,3,5)	1-5
7/11/72	7	30(6)	25(2)	7(1)	1-4,6
10/11/72	8	75(6)	50(1,4)	2(5)	1-6
14/11/72	7	130(4)	34(3)	10(2,6,6)	1-4,6
21/11/72	10	120(8)	75(4)	3(1)	1,3,4,6-8
28/11/72	12	65(8)	55(7)	3(2)	1-4, 6-8

TABLE 2. CARBON MONOXIDE LEVELS EACH DAY, IN PARTS PER MILLION

Results of the tests for Nitrous Oxides were as follows:

Station 1.	3 negative results
Station 2.	No tests for NOx
Station 3.	No tests for NOx
Station 4.	2 negative results. 1 reading of 0.25 p.p.m.
Station 5.	No tests for NOx
Station 6.	3 negative results. 1 reading of 0.5 p.p.m.
Station 7.	2 negative results. 1 reading of 0.5 p.p.m.

According to WHO figures, one would expect that in urban areas the NOx concentration would usually be less than 0.1 p.p.m., but that in some cases it could rise as high as 1.0. p.p.m.

Remembering that less than 0.1 p.p.m. would give a negative result on the Drager tube, these figures agree with our actual results values of 0.25 p.p.m. were obtained in a few cases. It therefore appears that as far as Nitrous Oxides are concerned the air in certain urban areas of Trinidad is comparable with that in big cities

A comparison on the WHO figures (previously quoted) for Carbon Monoxide, with our results, tends to reinforce this conclusion

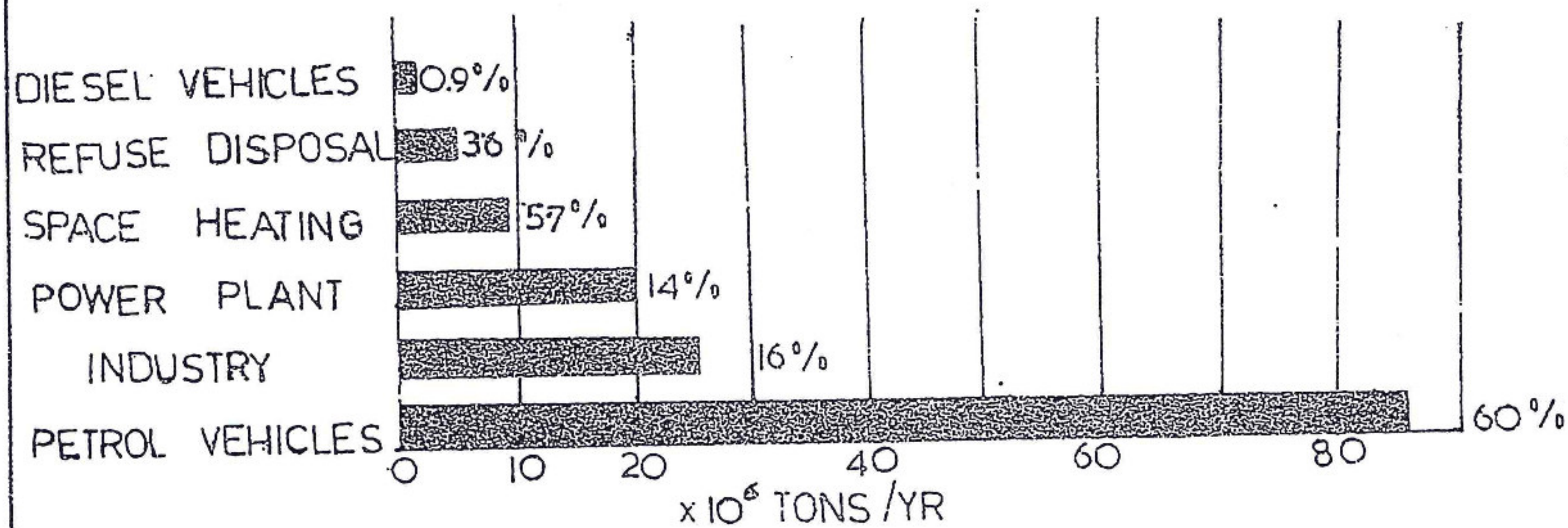

FIG.1. RELATION BETWEEN VARIOUS SOURCES OF POLLUTANTS IN U.S.A., 1966

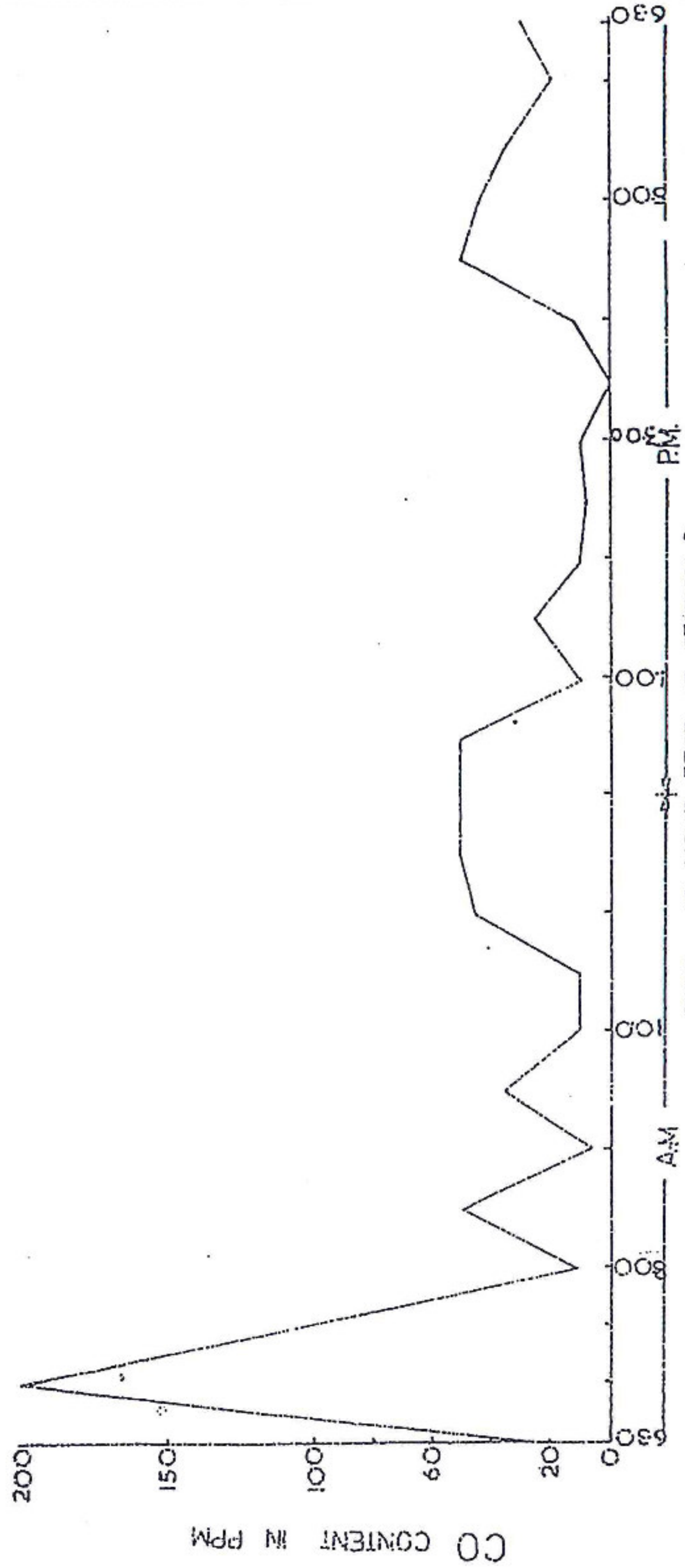

FIG.2 12 HOUR TEST AT STATION 8
CARRIED OUT ON DECEMBER 5. '72

The CO tests carried out, failed to show any definite correlation between pollution levels and weather conditions. However, a definite pattern emerges when comparing pollution levels between different stations. According to the CO figures, Stations 4, 6, 7, 8 were the most polluted stations, while NOx was only detected at Stations 4, 6, 8.

These stations share some common features; they are all on roads that can be considered main arteries, Wrightson Road in the case of Station 4, the Eastern Main Road in the case of the other three. They all are subject to heavy traffic jams and stop and start conditions during the rush hours, when the use of traffic policemen becomes necessary.

Of the other four stations, Nos. 1 and 5 are also on main highways. However, as previously mentioned, the ventilation at station 1 is very good, which assists the dissipation of exhaust fumes and accounts for the comparatively low readings at this point.

Station 5 gave the lowest readings of all. This point is in St James, on the Western side of Port of Spain, where the traffic problem is not as acute as in the Port of Spain - Arima corridor.

The results at Stations 2 and 3 indicate that the problem of pollution is less serious in the heart of Port of Spain than on the roads feeding traffic from the east into the capital.

The 12-hour test carried out at Station 8 is to be considered separately, since it covers not merely rush hour levels but the complete day.

Figure 2 shows graphically the results of that test. Weather conditions were very constant during the day, with bright sunshine throughout the day, but wind speed increased somewhat from 9.00 a.m. onwards.

The shape of the graph shows quite clearly how the times of high pollution levels coincide with times of peak traffic - 7.00 8.30 a.m., 11.00 a.m., – 12.30 p.m., 4.30 - 5.30 p.m.

The period between the last two peaks seems to be sufficient to allow the CO level to drop quite satisfactorily, only to rise again at the evening peak. It will be noted that the evening (4.30p.m.) pollution maximum is much lower than that in the morning. This may be due to the greater wind velocities in the evening of that particular day, or alternatively to lower traffic densities.

The arithmetic average of the readings taken at ½ hour intervals over a 12-hour period at Station 8, is 36 parts per million CO. Even if the high 7.00 a.m. reading of 200 p.p.m. is excluded, and there seems to be no reason for doing, the average would still be (29-30) p.p.m.

ANALYSIS OF RESULTS

At present there is some divergence of opinion as to what constitutes an acceptable level of Carbon Monoxide in the atmosphere.

The State of California has established that an ambient air quality standard should be 30 p.p.m. CO maximum 8-hour concentration and 120 p.p.m. maximum 1-hour concentration[8]. The U.S. Environmental Protection Agency has laid down more stringent standards of 9 p.p.m. CO maximum 8-hour concentration, not to be exceeded more than once per year, and 35 p.p.m. maximum 1-hour concentration; but to be exceeded more than once per year[9].

The latter standards have come in for some criticism as being too drastic; on the other hand however, J.C. Esposito, in "The Vanishing Air", quotes a paper from the National Academy of Sciences as follows " daily average in excess of 10 p.p.m. may be associated with increased mortality in **hospitalised** patients with heart diseases".

To understand the health implications of a given CO level some knowledge of the effects of the gas on the body is essential. Briefly, the gas combines with the haemoglobin in the blood to form the compound Carboxy haemoglobin. This decreases the oxygen-carrying capacity of the blood and progressively produces intoxication, headache, fatigue, unconsciousness and ultimately death[1].

The gas is odourless and non-irritant, so that the victim can inhale it freely without realising his danger. At the concentrations which are likely to occur in heavily-polluted air, its most insidious effect is that it may produce a state of intoxication which can affect a person's ability to carry out certain tasks such as driving a motor vehicle. In this respect, CO "intoxication" may be compared with alcoholic intoxication. Just as a driver's ability may, unknown to him, be impaired by alcoholic consumption, the same effect may be produced by CO inhalation(1).

A substantial amount of research has been carried out to determine what level of CO in the blood constitutes a danger signal. The extent to which a person has absorbed the gas is usually expressed as a percentage of the total Carbon Monoxide required to saturate the blood; for instance, the blood of a heavy smoker may be as much as 15% saturated with CO immediately after a period of chain smoking[2].

Moureu 1963[2] concluded that a non-smoking driver's manual dexterity is impaired at 4.8% saturation and over. In his opinion, many accidents attributed to alcoholic intoxication may in fact be due to carbon monoxide poisoning.

Horder et al[2] working the same year as Moureu, considered that 10% was the "danger level". Bowden and Woodwall[2] working in 1964 considered 5% as the "serious" level in a non-smoker. They concluded that if an accident victim is a non-smoker, a level of over 10% blood saturation may indicate that the accident was due to Carbon Monoxide poisoning.

The California State standards are based on the conclusion that the specified acceptable maximum levels would produce 5% blood saturation in persons inhaling these concentrations.

Figure 3 is based on a WHO report(8). All curves are drawn on the assumption that the subject is functioning on a low level of activity. A person engaged in strenuous exercise would inhale more rapidly and the CO content of his blood would rise more quickly.

For each CO level, there is a maximum blood saturation level which will be attained regardless of how a person is exposed to this level. This is shown on the curve marked "equilibrium". The other two curves provide a useful yardstick for determining what should be the maximum allowable concentration of the gas. The WHO report on which Figure 3 is based, recommends 4% saturation as the "threshold" level, and if this is accepted, Figure 3 indicates that the maximum 8-hour concentration should be 28 parts per million, and the maximum 1-hour concentration 110 p.p.m.

By any of the three references quoted, i.e. the WHO report, the California State Standards or the U.S. Environmental Protection Agency Standards, the air at Curepe Junction (Station 8) must be considered unsatisfactory. Figure 2 indicates a 1-hour concentration of 110 p.p.m. and an overall 12-hour average concentration of 36 p.p.m. In other words, the quality of the air at Curepe Junction is on the wrong side of the threshold.

Our other tests have indicated that Station 4, 6 and 7, also scenes of high pollution, are not as badly off as Curepe. Nevertheless, the situation at these points gives no cause for complacency.

The overall conclusion to be drawn from this investigation is that the problem of motor vehicle air pollution definitely exists in Trinidad, and it requires attention. Our results give no cause for alarm or panic, but they definitely indicate that steps must be taken to keep an eye on the situation and prevent its further deterioration.

CONCLUSIONS AND RECOMMENDATIONS

At present the condition of the air in some of our built-up areas is approaching the pollution levels of larger countries. With an ever-increasing number of vehicles on the roads of Trinidad and Tobago, one can expect our air quality to deteriorate further, if no remedial action is taken.

Such remedial action can take one of two forms, viz:

(a) Measures to reduce traffic congestion

(b) Measures to reduce the amount of pollutants emitted by each vehicle.

The traffic problems at Stations 4, 6, 7 and 8 are legacies of poor highway design; at all these points there is no provision for easy right turns from the secondary road to the main road. Congestion at Station 4, would easily be reduced by prohibiting right turns altogether, but this would not be a practical proposition at the other points.

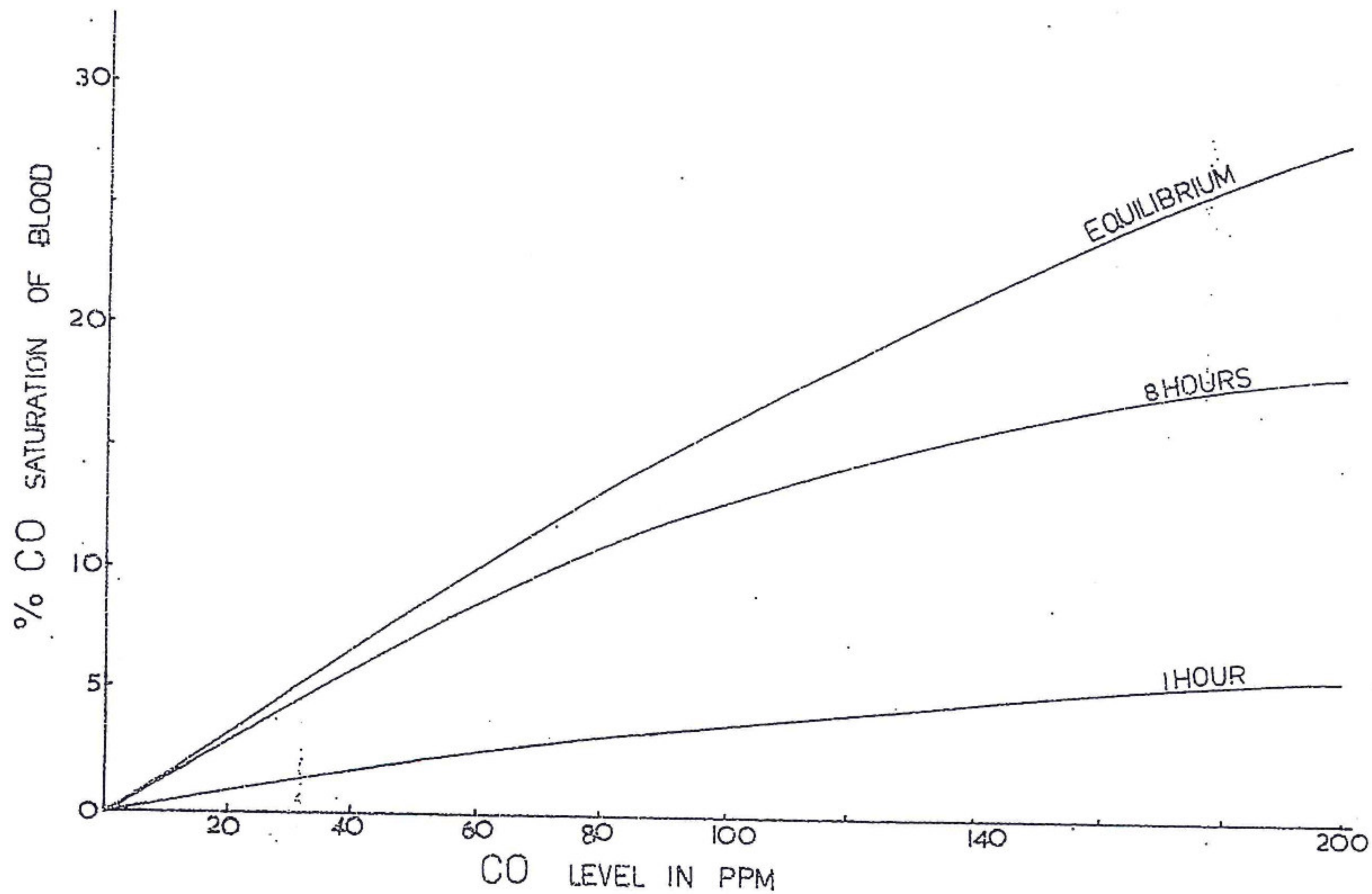

FIG.3 EFFECT OF EXPOSURE TO VARIOUS CO LEVELS.

More long-term solutions under (a) could include (i) the construction of an additional road from Arima to Port of Spain. It has already been accepted that such a road is urgently required; (ii) an improvement in the public transport system, to encourage commuters to switch from using their own vehicles.

Under (b) steps to reduce the pollutants emitted by vehicles can be readily undertaken. First of all regulations should be drawn up as to what should be the maximum permissible Carbon Monoxide content in petrol and diesel engine exhausts under (i) idling conditions (ii) acceleration conditions (iii) cruising conditions.

Taxis and goods vehicles could be checked for compliance with these regulations when they undergo their annual inspection. The motor vehicle licensing regulations could also be amended to require private cars more than four years old to undergo annual inspection to check, inter alia, their exhaust emissions. In addition to all this, road checks on vehicles using the same type of low-cost apparatus as was used in our tests, could be made at irregular intervals by officials of the Transport Division.

SUGGESTIONS FOR FURTHER WORK

Further spot checks, in more detail, will have to be made from time to time, of pollutant levels at selected points. For the time being these checks may be carried out using the same apparatus as was used in the pilot survey. In the absence of any dramatic change in the situation, the acquisition of more expensive test apparatus would not be justified.

It is safe to say that the built-up areas along the Eastern Main Road will require very close examination; 12-hour checks similar to the one done at Curepe Junction may be carried out at different locations.

It may also prove instructive to carry out tests on motor vehicles exhaust gases to determine their pollutant content. This would be a necessary preliminary to establishment of standards for motor vehicle exhausts.

REFERENCES

1. *J. Glaister and E. Rentoul*
   Medical Jurisprudence and Toxicology (Livingstone, Edinburgh and London 1966)
2. *C.J. Polson and P.N. Tuttersall*
   Clinical Toxicology (Pitman Medical Publishing Co. London, 1969)

3. *Annual Statistical Digest for 1970, Central Statistical Office, Port of Spain*

4. *M. Eisenbud and L.R. Ehrlich*
Carbon Monoxide Concentration in Urban Atmosphere, Science
Vol. 176 - 14th April, 1972

5. *Clean Air and the Diesel*
Bulletin No. 983052 (Cummins Engine Co., Inc)

6. *M. Katz*
Measurement of Air Pollutants, Guide to the Selection of Methods (WHO, Geneva, 1969)

7. *WHO Technical Report Series No. 410*
Urban Air Pollution with Particular Reference to Motor Vehicles (WHO, Geneva, 1969)

8. *WHO Technical Report Series No. 506*
Air Quality Criteria and Guides for Urban Air Pollutants (WHO, Geneva, 1972)

9. *PAHO Technical Report No. 46 (1972)*
Eng. Ricardo Haddad, Advisor in Air Pollution
(Private Communication)

10. *Introduction to the scientific study of atmospheric pollution*
Ed. by B.M. McCormack (Redidel - Dordresht, Holland 1971)