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AIR QUALITY AND BIOLOGICAL CONTROLS OF WORKERS EXPOSED IN WORKING PREMISES CONTIGUOUS TO AN URBAN ROAD-TUNNEL

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Abstract

The purpose of the study is to evaluate the influence of an urban road tunnel in the atmosphere of contiguous working premises. Biological monitoring (COHb) on maintenance staff is added. Tunnel pollution levels are strongly correlated with the traffic intensity and influence the air quality of technical rooms in the same way as COHb concentration of employees.

Introduction

The air quality in working premises contiguous to a one-way road-tunnel is studied. This tunnel, 860 meters long, is located in Paris center, on the bank of the Seine river ; the traffic is very high, up to 4000 vehicles per hour. Maintenance staff in charge of ventilation systems remains in the working premises for several hours in a day. The purpose of this study was to provide informations on the influence of the tunnel air pollution on the indoor air quality in working premises and on the evolution of some biological parameters of the employees.

Experimental procedures

Sampling sites (fig 1)

Air samples are collected from May 27 to June 9, 1983 simultaneously in the subway and in the working premises. In the tunnel (TU.), the air sampling equipements are located about 5 meters above the ground level ; in the technical room AF3 (T.R.), the air is sampled in vicinity of breathing zone of workers.

Table 3 Technical room and tunnel : daily concentrations of the most measured pollutants.

Pollutants and units	T.R. average	T.R. max.	T.R. min.	TU. average	TU. max.	TU. min.	Ratio° TU/T.R.
$cm^3.m^{-3}$							
CO	6	15	2	30	41	11	5.00
NOx	0.31	0.44	0.14	0.92	1.29	0.14	2.97
$\mu g.m^{-3}$							
CH2O	21.2	37.4	9.9	41.0	79.6	16.7	1.93
Benzene	2.5	5.0	2.0	19.8	51.0	7.0	7.92
Toluene	46	62	34	464	590	210	10.09
Particles	137	240	65	294	410	135	2.15
Pb	3.00	4.17	1.76	12.00	11.20	4.26	4.00
Fe	4.00	10.60	0.94	8.20	11.40	3.49	2.05
Al	0.50	0.63	0.06	0.36	0.64	0.17	0.70
Cu	0.16	0.23	0.06	0.69	0.89	0.29	4.27
Zn	1.10	1.48	0.23	0.76	0.97	0.38	0.85
$ng.m^{-3}$							
B(a)A	2.1	3.6	1.1	24.3	33.0	3.5	11.57
B(a)P	3.1	5.2	1.6	19.1	24.0	3.5	6.37
B(ghi)P	15.3	24.0	9.0	69.6	83.0	24.0	4.55
IP	3.2	4.5	2.1	14.3	18.0	5.0	4.47
Coronene	9.0	16.0	4.3	31.4	40.0	12.0	3.49

°Ratio calculated with averages.

Several air samples (80 liters-Reuter Centrifugal Sampler) give the level of microbial contamination by the count of baterial colony forming particles (C.F.P.) after a two days incubation at 37°C and by the research of indicators (staphylococci, enterobacteria,...) C.F.P. m^{-3} are 3 times higher in the working premises (700 up to 3600) than in the tunnel (200 up to 1000), indicator bacteria are exceptionally isolated. The average carboxyhemoglobin (COHb) of the smoker equals 4 times that of the no-smoker one (table 4).

Table 4 Atmospheric level CO in the technical room and COHb during the working time (09a.m.-04p.m.).

	May31	June1	June2	June6	June7	June8	June9	June10
CO $cm^3.m^{-3}$	-	4	8	2	3	10	17	-
COHb (%)								
no smoker								
09 a.m.	1.00	1.08	1.04	0.93	1.00	0.99	0.93	1.14
04 p.m.	1.04	1.19	1.42	0.97	1.08	1.35	2.14	-
smoker								
09 a.m.	1.59	2.05	2.60	2.04	2.04	2.68	3.62	4.20
04 p.m.	3.34	3.20	4.46	3.20	2.97	3.62	5.96	-

Sampling procedures :

Physico-chemical determinations of automotive air pollutants, are made (table 1). Vehicles per hour counts are recorded, intensity and fluidity of traffic are evaluated by a video-system. On account of Seine river proximity and its possible spate, bacteriological determinations are added. Every day, workers blood is sampled at the beginning and at the end of working times for oxycarbonemy (COHb) measurements.

Table 1 Sampling and analysis procedures

Pollutants	Sampling duration	Analytical technics
CO	continuous	NDIR
NOx	continuous	Chémiluminescent method
formaldehyde	24 H	HPLC dinitrophenyl-hydrazone
benzene	24 H	G-C - FID
toluene	24 H	G-C - FID
particulate matter	24 H	gravimetry
9 metals	24 H	atomic abs. spectometry
11 H.P.A.	24 H	HPLC - fluorescence detector

Results

Tables 2 and 3 summerize physico-chemical results of the whole study. Five minutes maxima of CO and NOx are observed of from 11.00a.m.-2.00p.m. CO maxima are recorded on June 9 : 60 $cm^3.m^{-3}$ in the technical room, 147 $cm^3.m^{-3}$ in the tunnel. NOx maxima are noted in technical room : 1.65 $cm^3.m^{-3}$ the May 28 in the tunnel : 2.25$cm^3.m^{-3}$ the June 2.

Table 2 Cumulated frequencies (%) of five minutes concentrations reaching reference levels of CO and NOx.

CO levels $cm^3.m^{-3}$	T.R. %	TU. %	NOx levels $cm^3.m^{-3}$	T.R. %	TU. %
10	66.3	12.5	.2	27.3	11.7
20	89.5	18.1	.4	56.4	12.1
30	96.1	33.3	.6	78.5	12.5
40	98.5	59.8	.8	91.6	14.9
50	99.0	62.5	1.0	96.7	25.6
100	100	99.0	1.5	99.7	89.9
150	100	100	2.0	100	99.8

Discussion

In spite of the ventilation systems, the CO, NOx, particles, Pb, Fe, Cu, Coronene and Benzo(ghi)Perylene concentrations in the tunnel are very important. For all pollutants strong correlations are found with one another and with the traffic intensity (fig. 2 and 3). The indoor concentrations measured in the working premises are lower than the subway ones.
The indoor data statistical study shows that the pollutants are correlated with one another only in three independant groups ; first group : CO, NOx, Pb ; second one : particulate matter, other metals ; third one : H.P.A.

In the first group, the indoor concentrations are correlated with the tunnel ones (fig. 4 to 7). In the second group, no correlation is found with the tunnel concentrations excepted for particulate matter and Cu. Indoor concentrations of Al and Zn are higher than the tunnel ones. In the third group, no significative correlation is found with the indoor and the tunnel concentrations. The ratio "TU/T.R." is near 4 for the most H.P.A. and near 7 for Perylene, Benzo(a)Pyrene and Benzo(e)Pyrene. Preceeding studies (4, 5) have shown that these last H.P.A. are photochemically transformed by light from their emission in the tunnel to their intake in the technical room.

Consequently the indoor pollution levels may be explained by three phenomenons : - a direct influence of the tunnel pollution for CO, NOx, Pb and particulate matter, in a same ratio, 20 % - a slight influence of the tunnel pollution for H.P.A., even if the same ratio is found for several H.P.A., while the transformation of the other ones interfers on the phenomenon. - a possible specific indoor pollution by Al and Zn due to an eventual wear of ventilation systems.

The level of bacterial contamination in the tunnel is very low and near those usually found in outside atmosphere. In the technical room, the bacterial counts are about 3 times higher, but indicator germs are rarely isolated.

COHb rises during the work time (09a.m.-04p.m.). This increase and the average concentration of CO in the technical room atmosphere are significatively correlated (fig. 8) for the smoker and no-smoker.
The smoker's COHb augmentation is higher than the no-smoker's one. The morning measurements in the smoker's blood show an accumulation effect along the week reduced after the week-end. On the other hand, for the no-smoker's blood anslysis, the morning results are constant during the week and equal to those measured in the blood of no-smokers in urban area.

Conclusion

This study, in which many pollutants are measured, shows that the air quality in the working premises contiguous to the urban road tunnel is strongly influenced by the air pollution in it. Yet, the indoor concentrations are generally lower. The COHb of the workers in the technical room increases significatively but slightly and is directly correlated with the indoor CO concentrations. A specific indoor pollution by the metallic parts of ventilation systems is shown.

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