ASSESSMENT OF TRAFFIC INDUCED POLLUTION FROM THE NEW HIGHWAY OF ATHENS (ATTIKI ODOS)

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INTRODUCTION

Road transport in urban areas is a major source of air pollutants, such as CO, NO_x, particulate matter, and VOCs (*Gilbert, N. et. al.*, 2003). The degradation of air quality presents a serious threat on the health of the inhabitants, and traffic-induced pollution is currently one of the major problems of life quality in urban areas. This is particularly true in street canyons, where the combination of large vehicle emissions and reduced dispersion can lead to high levels of pollution (*Bakeas, E.B. and P.A. Siskos*, 2003). Highway traffic emissions result in small-scale spatial variations (high concentrations at short distances from major roads) and affect urban and regional background air pollution concentrations (*Vardoulakis, S. et al.*, 2002).

The greater Athens area experienced a rapid increase in passenger and freight transport hosting a fleet of approximately 1.500.000 vehicles. This combined with the lack of appropriate infrastructures and the poor ventilation of the area due to the frequent development of atmospheric inversions resulted in elevated pollution levels (*PERPA*, 1989; *Klidonas, Y.*, 1993). In order to improve the traffic conditions in the greater Athens area a modern high-speed closed type motorway, named Attiki Odos, was designed according to the the highest standards. The construction began in 1997 and the road was partly released for use since March 2001 till its full completion in the spring of 2004. The motorway connects more than 30 districts in Attica and it is linked to the International Airport "Eleftherios Venizelos" in Spata, the tow main National Roads, the suburban railway and numerous local public transport stations, etc. Attiki Odos consists of two main motorways, the Elefsina – Stavros – Spata A/P Motorway (ESSM), which extends to 52.4 km and the Imittos Western Peripheral Motorway (IWPM), which extends to 12.9 km (*http:\\www.aodos.gr*).

The assessment of traffic-induced pollution and the impact of the new highway Attiki Odos on the atmospheric quality in the greater Athens area – and especially in the vicinity of the high-speed road – was the aim of a project undertaken by the Institute for Environmental Research and Sustainable Development (IERSD), National Observatory of Athens.

METHODOLOGY

The impact on the air quality in the vicinity of Attiki Odos was assessed using Radiello passive samplers along with the on-line measurements of a mobile pollution monitoring station. The two main motorways of Attiki Odos, ESSM and IWPM, were examined separately, and the campaign covered two different periods: a) Phase A, before the beginning of the motorways' operation, and b) Phase B, after their opening. Details about the dates of the campaign and the number of the sampling or monitoring points for each motorway are shown in Table 1.

Table 15. Dates of the campaign and number of sampling and monitoring points for the two motorways of Attiki Odos

	ESSM	IWPM
Sampling		
Phase A dates	20-24/01/2003 and 28-31/01/2003	16-23/07/2003
Phase B dates	07-10/04/2003	21-26/09/2003
On-motorway points	10	5
Peripheral points	24	17
Total points	34	22
Monitoring measurements		
Phase A dates	21-31/01/2003	16-30/07/2003
Phase B dates	08-18/04/2003	22/09-06/10/2003
On-motorway points	3	2

Sampling points were selected, taking account traffic and meteorological conditions and the possibility of dispersion or transport of air pollutants, as well as the interaction between emissions and the existing road network (e.g. main intersections). An additional criterion for the site selection of the mobile station was the need for electric power supply. The passive samplers performed measurements over a period of days that could be used for comparing the pollutants concentrations at one site during two different time periods, whereas the measurements of the mobile station were indicative of daily trends of traffic pollutants.

Within the framework of the study, measurements of O_3, NO_2, benzene (C_6H_6), and toluene (C_7H_8) were acquired from passive samplers. In addition, the mobile station measured concentrations of the main pollutants O_3, NO_x, CH_4, NMHC, CO and PM_{10}, as well as basic meteorological parameters, i.e. air temperature, relative humidity, pressure, and wind direction and speed.

Sample analysis was performed at the IERSD laboratory with the methods of double-beam UV-VIS spectroscopy and multiple ionisation mass spectrometry. Concentration values from the mobile station were compared with the EU and the Greek national limit values as well as with the WHO target values of air quality. Since passive sampler measurements are inherently spatially averaged, these were used to assess the relative impact of each motorway on air quality. For this reason, the inverse distance interpolation with ArcView 3.2 was used in order to produce maps of the area representing concentration differences between measurement Phases A and B.

RESULTS

As expected, the analysis of the mobile station measurments shows high values of pollutant concentrations during rush hours (in the morning and in the afternoon), while the effect of wind is also significant. Hourly variations of NO and NO_2 follow the same pattern, contrary to O_3 variation. CO is proportionally related with NMHC, implying their common origin. On the other hand, CH_4 variations do not relate with NMHC variations, while PM_{10} are characterised by intense peaks.

Table 2 provides aggregate passive sampler data for each motorway and Phase. Maps of ESSM and IWPM depicting NO_2 and benzene concentration differences between the two Phases are shown in Figures 1 and 2. White and light shaded areas indicate higher concentrations during Phase A than in Phase B, while darker shaded areas were negatively affected by the operation of Attiki Odos. Concentrations of NO_2, C_6H_6 and C_7H_8 decreased in

Phase B, mainly at the west part of Athens (Herakliou Avenue), as well as in the areas of Halandri and Pallini. The opposite happened at the region of Gerakas, at the western part of Mesogeion Avenue and in main roads close to IWPM. In the vicinity of ESSM, large increases of O_3 were noted in the greater area of Halandri, in Phase B, whereas, decreased O_3 values were measured in Gerakas and in the area around IWPM, mainly due to high concentrations of NO_x.

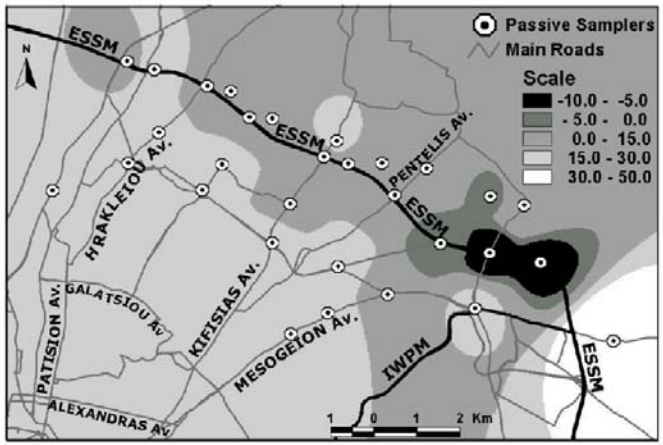
Table 16. Statistical data of NO_2, O_3, benzene and toluene concentrations for ESSM and IWPM, Phase A and B

Parameter	NO_2 ($\mu g/m^3$)	O_3 ($\mu g/m^3$)	C_6H_6 ($\mu g/m^3$)	C_7H_8 ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	O_3 ($\mu g/m^3$)	C_6H_6 ($\mu g/m^3$)	C_7H_8 ($\mu g/m^3$)
Phase A	ESSM sampling points				Peripheral sampling points			
Mean	27,0	36,2	2,6	0,4	34,1	30,3	2,6	0,3
Standard deviation	8,3	12,5	0,9	0,2	14,4	15,8	0,8	0,2
Maximum	38,9	58,3	4,2	0,8	67,1	70,8	4,4	0,9
Phase B	ESSM sampling points				Peripheral sampling points			
Mean	22,0	27,1	2,2	0,3	20,3	33,5	2,3	0,2
Standard deviation	2,8	5,6	1,0	0,1	6,1	12,7	3,7	0,1
Maximum	27,1	36,5	4,3	0,5	37,9	63,9	18,9	0,6
Phase A	IWPM sampling points				Peripheral sampling points			
Mean	11,3	82,7	8,3	0,1	24,5	79,4	5,4	0,2
Standard deviation	5,0	40,9	3,3	0,1	9,6	26,5	3,0	0,1
Maximum	16,5	125,7	11,4	0,2	47,7	130,9	10,5	0,5
Phase B	IWPM sampling points				Peripheral sampling points			
Mean	21,4	40,9	12,0	0,2	35,4	33,2	7,8	0,5
Standard deviation	5,7	7,4	5,0	0,2	13,3	8,6	5,7	0,7
Maximum	28,3	51,2	16,8	0,6	63,2	49,3	24,1	2,9

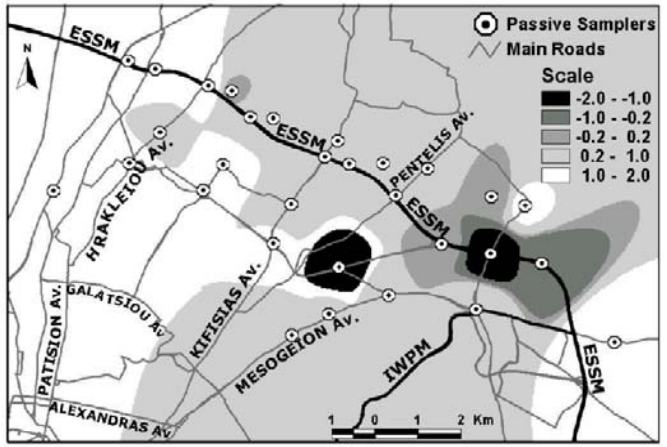
DISCUSSION

Regarding the sampling points on ESSM, the reduced concentrations of NO_2, C_6H_6 and C_7H_8 during the operation period (Phase B) are possibly due to the normal traffic flow on the highway. Few exceptions (Plakentia, Klisthenous and Gerakas intersections) are noted probably because of the increased peripheral traffic in these regions. Reduced concentrations of the pollutants mentioned before are also observed in the areas around ESSM. The reason is probably the relief of the roads that cross the highway and the increase of the mean speed of vehicles. As expected, ozone values vary conversely to NO_2.

On the contrary, IWPM has several tunnels resulting in high concentrations of NO_2, C_6H_6 and C_7H_8 along the highway. In a tunnel, car emissions are not diffused in the atmosphere immediately, but they follow the way of the vehicles to the exit of the tunnel, aided by the ventilators of the tunnel. The result is to measure high concentrations of pollutants in the vicinity of the tunnels. High values of NO_2, C_6H_6 and C_7H_8 were also measured on the roads close to IWPM. This is probably due to the fact that IWPM has little to do with local traffic – its main function is to connect the southern and northern suburbs. This however, leads to increased traffic in the region that has a great impact on air pollution in the areas around IWPM.

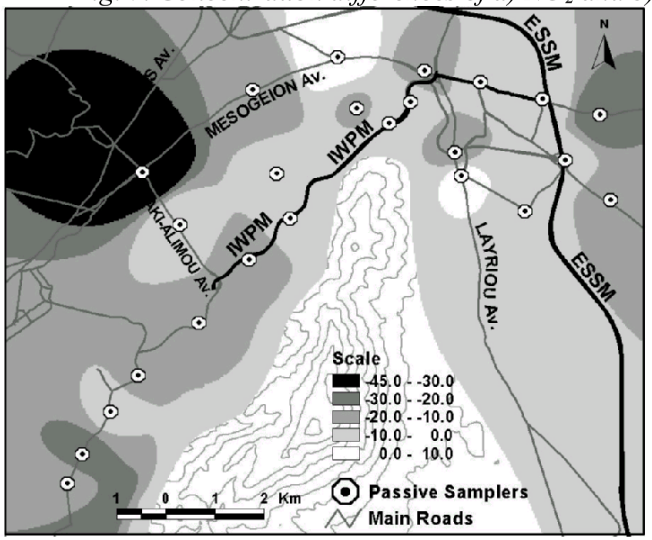


(a)



(b)

Fig. 7. Concentration differences of a) NO_2 and b) benzene between Phase A and Phase B in the vicinity of ESSM



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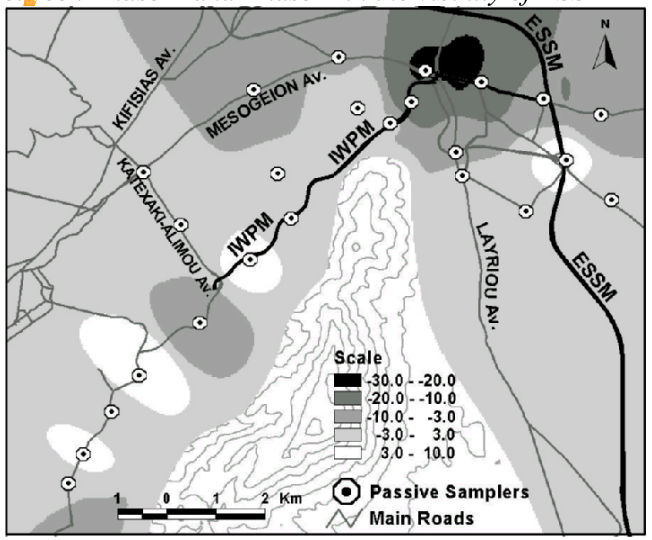

(b)

Fig. 8. Concentration differences of a) NO_2 and b) benzene between Phase A and Phase B in the vicinity of IWPM

It should be mentioned that during the time periods of the measurements (Phases A and B), many construction works were active in the study area, with inevitable impacts on traffic and consequently on the air quality. Therefore, it is very important to point out that any conclusions from this study can only be considered as indicative, as they contain the impact from all the works that were active during the study periods.

CONCLUSIONS

The work presented herein assesses the impact of the new highway "Attiki Odos" on the atmospheric quality in the Greater Athens area.

The operation of ESSM, lead to decreased concentrations of primary pollutants (NO_2, C_6H_6 and C_7H_8), mainly at the western part of Athens and in the area of Halandri. Significant pollution decrease also appeared in the area around Pallini, an eastern suburb of Athens, on the contrary to Klisthenous intersection. High values of O_3 were noted in the greater area of Halandri, while Gerakas was not polluted with O_3.

After the opening of IWPM, concentrations of NO_2, C_6H_6 and C_7H_8 increased almost everywhere around the motorway, especially in Mesogeion Avenue and on the main roads connected with IWPM. Due to NO_x presence in these areas, O_3 concentration was kept at low levels. In general, decrease of O_3 concentration was accompanied with high concentrations of primary pollutants, which seem to be directly connected to the traffic load and the operation of tunnels on the motorway.

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