

Air quality in the Mesogaia Plain in Eastern Attica before and after the opening of the Athens International Airport

C. M. O'Connor, E. P. Anamaterou & E. G. Leivaditis
*Environmental Department, Athens International Airport S.A.,
Athens, Greece*

Abstract

As part of its environmental responsibilities, the Athens International Airport “Eleftherios Venizelos” has been monitoring air quality in the Mesogaia Plain since late 1998, well before the opening of the airport in March 2001. Several years worth of air quality and meteorological data were analysed in order to identify possible changes in regional air quality. It was found that, in general, air quality in the Mesogaia is satisfactory. Furthermore, a comparison of a two-year period prior to the opening of the airport with a two-year period following the initiation of operations revealed no noticeable impact of airport operations on air quality in the Mesogaia. Apart from ozone and particulate matter, pollutant levels are significantly lower than those observed in the city center of Athens and well below both current and future air quality thresholds. Observed concentrations of particulate matter do not exceed current thresholds, but if levels remain unchanged the stricter thresholds coming into effect in the next few years may likely be exceeded in some areas of the Mesogaia. Future work will focus on continued monitoring as well as the development of an aircraft emissions inventory.

Keywords: air pollution, regional air quality, ozone, particulate matter, airports, aircraft emissions.

1 Introduction

The greater metropolitan area of Athens, Greece has a history of air quality problems. A number of factors are responsible for this situation, including a high population density, a variety of industrial activities, the climate and the local



topography, which is not conducive to ventilation. A number of experimental and numerical modelling studies have been performed to address this issue [1, 2]. The problems are not limited to the city center, particularly as development has extended into the regions surrounding the city.

The Mesogaia Plain is located in Eastern Attica, separated from Athens by the mountains of Imittos (1026 m) and Pendeli (1107 m). Land use has been predominantly agricultural in nature, but has changed significantly in recent decades, particularly with the construction of a superhighway (Attiki Odos) connecting the region with the city center, the new Athens International Airport "Eleftherios Venizelos" and other industrial and housing development. Information about air quality in the region is sparse. Only a limited number of measurement campaigns and modelling studies have been performed [3, 4, 5].

Athens International Airport S.A. (AIA) was established in 1996, including an Environmental Department that has been certified according to EN ISO 14001. As part of its environmental responsibilities, AIA installed and has been operating an Air Quality Monitoring Network (AQMN) since late 1998, under the supervision of the Hellenic Ministry of the Environment. The AQMN includes five permanent stations installed in the Municipalities of Glyka Nera, Koropi, Markopoulo, Pallini and Spata (see Figure 1) as well as one mobile station.

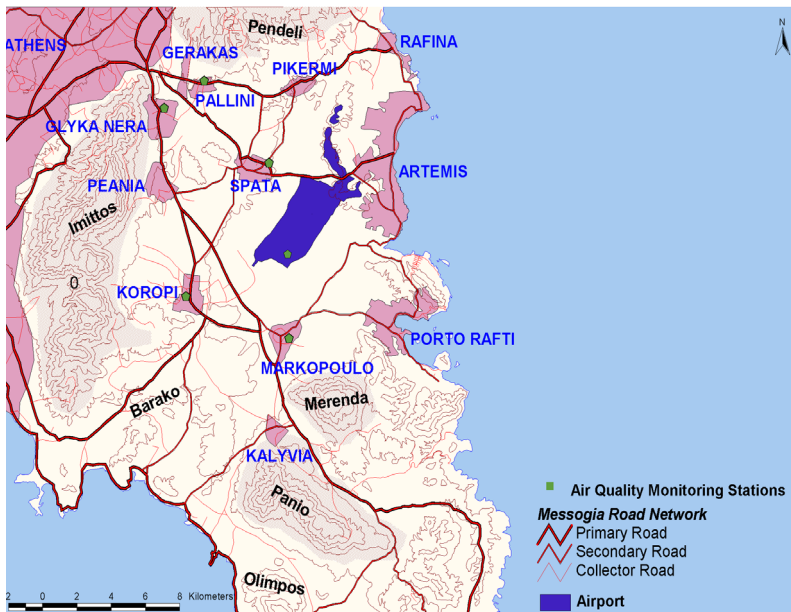


Figure 1: Map of Eastern Attica indicating the location of the five permanent stations of the AQMN.

The pollutants monitored by the AQMN include: ozone, oxides of nitrogen, particulate matter (PM₁₀), sulphur dioxide, carbon monoxide and hydrocarbons.



In addition, temperature, wind speed and direction and relative humidity are also monitored at each station.

The AQMN began operating in October 1998. Hence over two years of data were gathered prior to the opening of the airport in March 2001. This provided a unique opportunity to evaluate the impact, if any, of airport operations on local air quality by comparing pre-opening pollution levels with those recorded following the opening.

2 Methodology

The raw data are collected and processed to generate a high quality dataset [6, 7]. A total of four years of data were analysed during this exercise, selected in order to remove any potential seasonal bias. For the mobile station, only data from the location in the Municipality of Artemida is presented (corresponding to August 2000 through the end of the period of analysis). In addition, due to relocation of the station in Koropi following the Athens 1999 earthquake, no data is reported before November 2001. Other missing data points correspond to insufficient data capture.

3 Results

3.1 Ozone

Ozone is an important pollutant and limit values have been set for the protection of human health as well as vegetation [8, 9]. Figure 2 shows the mean monthly concentrations of ozone for each station of the AQMN.

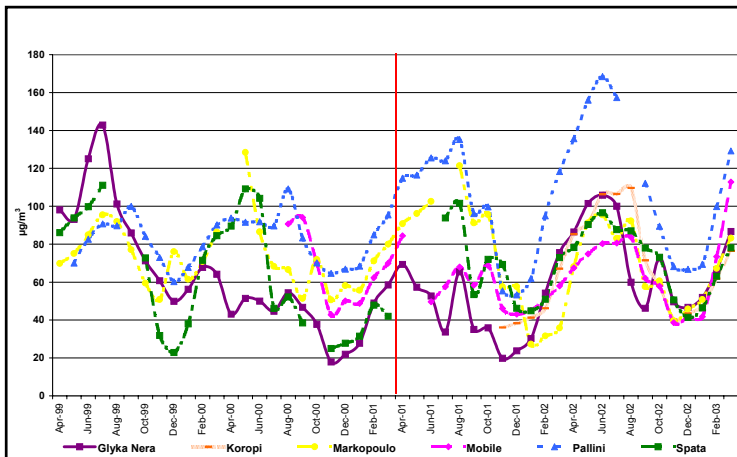


Figure 2: Monthly mean concentrations of O₃ (µg/m³).

Figure 2 indicates a strong seasonal pattern in ozone concentrations. Ozone levels are highest in Pallini, while the lowest concentrations are found in



Artemida (the mobile station). Ozone values are high but never exceed the population warning threshold ($360 \mu\text{g}/\text{m}^3$ for one hour recently amended to $240 \mu\text{g}/\text{m}^3$ for one hour). However, the population information threshold ($180 \mu\text{g}/\text{m}^3$ for one hour) and the health protection threshold ($110 \mu\text{g}/\text{m}^3$ for eight hours) are exceeded, particularly during the summer months. Looking to the future, the new health protection threshold ($120 \mu\text{g}/\text{m}^3$ for eight hours not to be exceeded more than 25 days per calendar year) will also likely be exceeded if current ozone levels do not change significantly.

3.2 Nitrogen dioxide

Nitrogen dioxide is a secondary pollutant that plays an important role in the production of ozone. Figure 3 shows the mean monthly concentrations of nitrogen dioxide for each station of the AQMN.

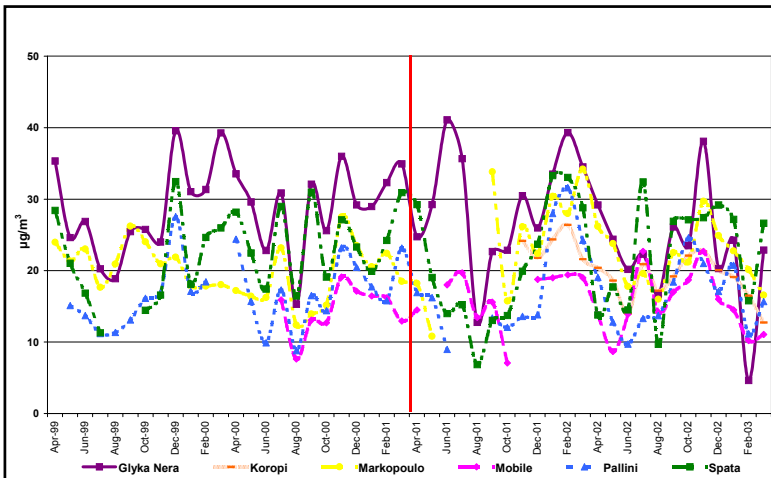


Figure 3: Monthly mean concentrations of NO₂ ($\mu\text{g}/\text{m}^3$).

The highest concentrations of nitrogen dioxide are found in the region of Glyka Nera, the AQMN station furthest from the airport. Nitrogen dioxide levels observed in the Mesogaia Plain are, as expected, considerably lower than those found in the city center of Athens. The current hourly ($200 \mu\text{g}/\text{m}^3$ not to be exceeded more than 18 times in a calendar year) and annual ($200 \mu\text{g}/\text{m}^3$ 98th percentile of hourly mean values) limit values for the protection of human health have not been exceeded at any station of the AQMN [10]. Barring any significant increases in nitrogen dioxide concentrations, the future annual limit value ($40 \mu\text{g}/\text{m}^3$) is also unlikely to be exceeded.

3.3 Particulate matter

Particulate matter is a pollutant of increasing concern due to its impacts on human health, visibility and material degradation. Figure 4 shows the mean



monthly concentrations of particulate matter (PM₁₀) for each station of the AQMN.

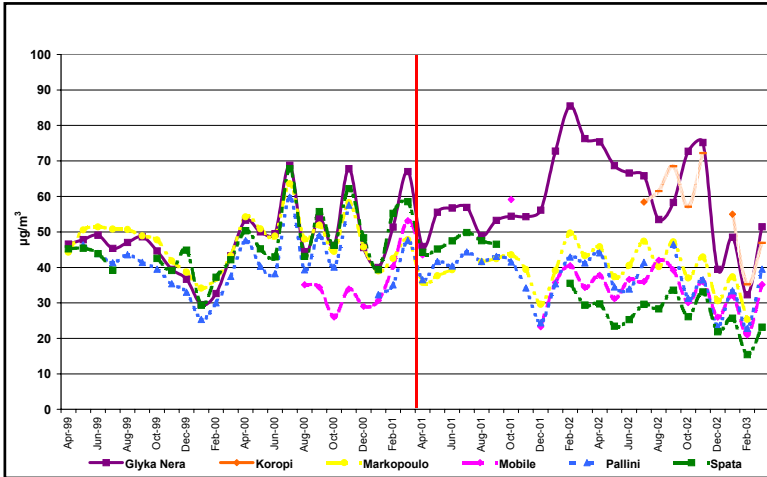


Figure 4: Monthly mean concentrations of PM₁₀ (µg/m³).

The between station variability increases noticeably as time progresses, possibly indicating the appearance of new station-specific sources. The comparatively high particulate levels observed in Glyka Nera are attributed to large-scale infrastructure works taking place in the area since early 2001. Other important sources of particulate matter in the Mesogaia Plain include: the nearby sea, mining and quarrying activity, agriculture (e.g., agricultural burning), motor vehicles, and light industry.

The current annual limit value for PM₁₀ (80 µg/m³ median of daily mean values) has not been exceeded. However, the increasingly strict annual (and daily) limit values that will come into force in two stages (2005 and 2010) will likely be exceeded in some areas of the Mesogaia Plain [10].

3.4 Sulphur dioxide

Sulphur dioxide emissions derive from the combustion of sulphur-containing fuels. Figure 5 shows the mean monthly concentrations of sulphur dioxide for each station of the AQMN. Sulphur dioxide is not monitored at the stations in Koropi and Markopoulo.

As with nitrogen dioxide, sulphur dioxide levels observed in the Mesogaia Plain are significantly lower than those measured in Athens. Concentrations are well below the current annual limit value (80 µg/m³ median of daily mean values). It is also highly unlikely that future hourly (350 µg/m³ not to be exceeded more than 24 times in a calendar year) and daily (125 µg/m³ not to be exceeded more than 3 times in a calendar year) limit values will be exceeded [10].



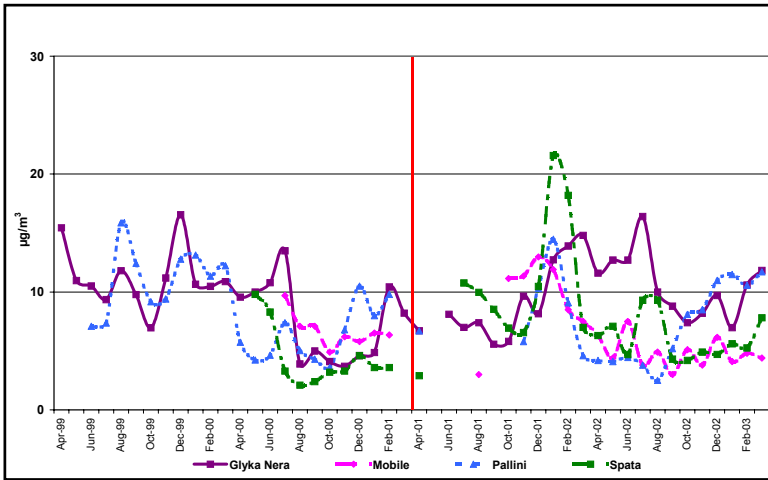


Figure 5: Monthly mean concentrations of SO₂ (µg/m³).

3.5 Carbon monoxide

CO is an important primary pollutant deriving mainly from motor vehicle emissions. Figure 6 shows the mean monthly concentrations of carbon monoxide for each station of the AQMN.

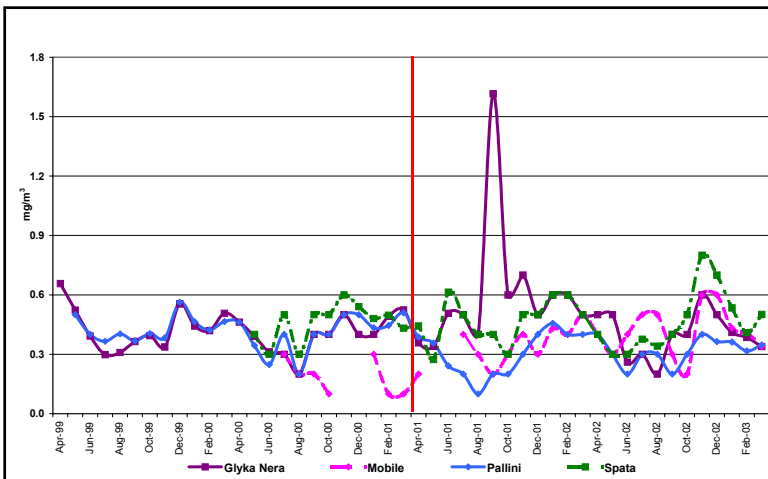


Figure 6: Monthly mean concentrations of CO (mg/m³).

Carbon monoxide levels observed in the Mesogaia Plain are very low and well below the limit value for the protection of human health (10 mg/m³ maximum daily 8-hour mean) that will come into effect in the year 2005 [11].



3.6 Daily variation

The daily variation of pollutant levels was also analysed. Figure 7 presents the hourly values for all pollutants averaged over the entire sampling period for the mobile station while it was located in the Municipality of Artemida. The results show the impact of the morning commuter traffic (07:00 – 09:00), specifically for the pollutants directly related to motor vehicle emissions (i.e. carbon monoxide and nitrogen dioxide). A secondary peak occurs late in the evening. As expected, ozone levels are consistently anticorrelated with nitrogen dioxide levels. The peak ozone concentrations occur between two and four o'clock in the afternoon, once temperature and solar radiation have reached their maximum. Ozone concentrations drop considerably during the morning commute hours as nitric oxide emissions peak. Sulphur dioxide and particulate matter exhibit less distinctive daily patterns.

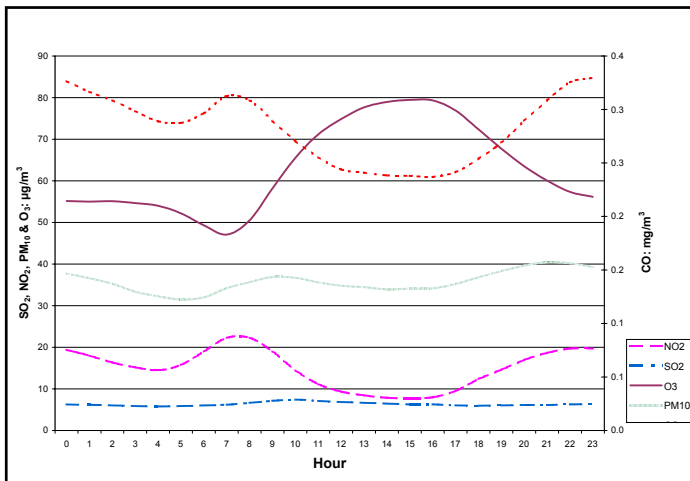


Figure 7: Daily variation in the Municipality of Artemida.

3.7 Before versus after

The primary objective of this exercise, apart from analysing a history of several years of air quality data from the Mesogaia Plain, was to determine if the opening of the Athens International Airport in March 2001 had any impact on local air quality. Pollutant concentrations were averaged over the two time periods: 'Before' (1 April 1999 through 31 March 2001) and 'After' (1 April 2001 through 31 March 2003). The results are presented in Table 1.

Data from the station in Koropi are not included due to the aforementioned difficulties following the 1999 Athens earthquake. Sulphur dioxide and carbon monoxide are not measured at the station in Markopoulo.



Table 1: Before and after.

Station		Glyka Nera	Markopoulo	Mobile	Pallini	Spata	Average
O₃ ($\mu\text{g}/\text{m}^3$)	Before	63,3	73,4	66,1	82,5	63,2	73,0
	After	59,5	71,4	62,8	102,9	70,3	73,4
NO₂ ($\mu\text{g}/\text{m}^3$)	Before	28,9	20,0	14,6	16,7	22,7	21,0
	After	26,0	22,9	15,8	17,3	22,0	20,8
PM₁₀ ($\mu\text{g}/\text{m}^3$)	Before	47,9	47,3	35,3	41,1	46,5	44,8
	After	59,4	39,7	35,5	37,2	33,1	41,0
SO₂ ($\mu\text{g}/\text{m}^3$)	Before	9,3	-	6,7	8,6	4,4	7,7
	After	9,9	-	6,6	7,6	8,0	8,0
CO (mg/m^3)	Before	0,4	-	0,2	0,4	0,5	0,4
	After	0,5	-	0,3	0,3	0,5	0,4

4 Discussion

Based on the results shown in Table 1, the following remarks can be made:

- Following the opening of the airport, ozone concentrations have dropped in Glyka Nera, Markopoulo and Artemida (the mobile station), but increased in Spata and risen significantly in Pallini.
- Nitrogen dioxide levels have not changed significantly since March 2001.
- Particulate matter concentrations have fallen remarkably in Spata and Markopoulo following the airport opening, likely due to the completion of the airport construction works, significantly reducing the amount of airborne dust generated.
- On the contrary, PM₁₀ levels have increased in Glyka Nera, where, as pointed out previously, large-scale infrastructure works are still in progress.
- Carbon monoxide levels have not changed considerably during the examined period.
- With respect to sulphur dioxide, the most noticeable change is a near twofold increase at the station in Spata. However, it must be pointed out that the increased levels (less than 10 $\mu\text{g}/\text{m}^3$) are still much lower than the concentrations observed in the center of Athens and are also well below both current and future air quality thresholds for this pollutant. In addition, analysis of the prevailing winds recorded at the station revealed that most of the sulphur dioxide transported to the site comes from the west-northwest direction (the airport is located to the southeast of the station).
- The problematic air pollutants in the Mesogaia Plain identified through this work are ozone and particulate matter, particularly in light of the fact that stricter air quality thresholds for both pollutants will be coming into force in the next several years.
- At this time and according to the data collected thus far, air quality in the Mesogaia has not changed noticeably following the initiation of operations at the Athens International Airport in March 2001.



With respect to regional differences in the Mesogaia Plain, the following comments can be made:

- Ozone levels are considerably higher in Pallini than in any other region in the Mesogaia Plain.
- Nitrogen dioxide levels are fairly consistent between regions with slightly more NO₂ observed in the Municipality of Glyka Nera.
- Concentrations of particulate matter are highest in Koropi followed by Glyka Nera. The data history for Koropi is not as extensive as that for the other stations of the AQMN due to the relocation of the station following the earthquake of September 1999. Hence, further data must be collected to ensure the validity of these levels.
- Both carbon monoxide and sulphur dioxide levels are comparable throughout the Mesogaia.

5 Conclusions

In conclusion, air quality in the Mesogaia Plain can, in general, be considered very satisfactory. The main atmospheric pollutants exist at significantly lower levels than those observed in the center of Athens. In addition, most pollutant concentrations are well below both current and future air quality thresholds. These results are consistent with the forecasts of the Airport's Environmental Impact Assessment [3] as well as with the results of other studies performed in the area [7]. Future AIA efforts will focus on continued monitoring as well as further investigation of the problematic pollutants, ozone and particulate matter, particularly the role of regional transport for ozone.

References

- [1] Kallos, G., Kassomenos, P. & Pielke, R.A., Synoptic and mesoscale weather conditions during air pollution episodes in Athens, Greece. *Boundary-Layer Meteorology*, **62**, pp. 163-184, 1993.
- [2] Kassomenos, P., Study of the atmospheric conditions prevailing during air pollution episodes in the greater Attika area. Ph. D. Dissertation, Department of Applied Physics, University of Athens, pp. 362, 1993.
- [3] TRADEMCO Consulting Engineers, Environmental Impact Study for the Athens Airport S.A., 1992.
- [4] Helmis, C.G., Asimakopoulos, D.N., Papadopoulos, K.H., Kassomenos, P., Kalogiros, J.A., Papageorgas, P.G. & Blikas, S., Air mass exchange between the Athens Basin and the Messogia Plain of Attika, Greece. *Atmospheric Environment*, **31(22)**, pp. 3833-3849, 1997.
- [5] National Technical University of Athens & Aristotle University of Thessaloniki, Air quality monitoring program around the new airport of Spata in the Messogia area. Final report, pp.168, 1998.
- [6] Anamaterou, E.P., O'Connor, C.M., Sarkissian, M.N., Raftopoulou, C.I., Leivaditis, E.G., Hatzis, C., Assimakopoulos, V.D. & Flocas, H.A., The



- Athens International Airport and air quality. Proc. of Air Pollution 2004, Rhodes, Greece, 2004.
- [7] Flocas, H.A., Hatzis, C. & Assimakopoulos, V.D., Air quality assessment report for Mesogia, period: January 2000 - June 2002, University of Athens, Department of Physics, Section of Applied Physics, pp. 52, 2002.
- [8] Council Directive 92/72/EEC of 21 September 1992 on air pollution by ozone.
- [9] Directive 2002/3/EC of the European Parliament and of the Council of 12 February 2002 relating to ozone in ambient air.
- [10] Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air.
- [11] Directive 2000/69/EC of the European Parliament and of the Council of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air.

