ABSTRACT

The Chariiakos Trikoupis bridge, known as bridge of Rio–Antirrio, is one of the world’s longest cable-stayed bridge of multiple openings in the world, with a total length of 2,252 meters. It connects Western Greece with the rest of the country. In this study an overview of the air pollution monitoring in the area in 2013-2014 is presented. Four campaigns were realized in the course of the last two years. The exact periods of the two annual campaigns were selected taking into account the high traffic seasons according to a careful examination of the bridge traffic patterns. In each of the campaigns PM$_{2.5}$, PM$_{10}$ and TSP were sampled every 24 hours near the edges of the bridge located in the urban areas of Rio and Antirrio, using low-volume automatic sequential samplers. Dynamic measurements of CO, NO, NO$_2$, SO$_2$, PM$_{2.5}$ and PM$_{10}$ were also performed continuously during the 10-day periods. TSP were collected on quartz filters (203 mm × 254 mm) in order to determine lead (Pb). Lead concentrations were measured using an inductively coupled plasma mass spectrometer (ICP-MS). Moreover, meteorological data (wind speed and direction, temperature, cloud cover and humidity) were recorded. The pollution data were analyzed statistically and the quality of the air was characterized according to the US Environmental Protection Agency indicators and the European Common Air Quality Index framework.

The results indicated that air pollution levels are in generally below the regulatory thresholds. Across the three summer sampling sessions (N = 10 days) the average PM$_{10}$ daily concentrations at the Rio site were 19.7 μg/m$^3$, 20.1 μg/m$^3$, 19.2 μg/m$^3$ only slightly higher than that at the Antirrio site that were 17 μg/m$^3$, 17.5 μg/m$^3$ and 12.6 μg/m$^3$ (for the 1$^{st}$, 3$^{rd}$, 4$^{th}$ periods respectively). The PM$_{2.5}$ were 8.7 μg/m$^3$, 10.61 μg/m$^3$, 8.9 μg/m$^3$ at Rio site while at Antirrio were 7.8 μg/m$^3$, 9.22 μg/m$^3$, 7 μg/m$^3$ (for the 1$^{st}$, 3$^{rd}$, 4$^{th}$ periods respectively). Moreover, the traffic emissions from the bridge are not the main source of air pollution in the area. During the winter period of sampling (2$^{nd}$) PM$_{2.5}$ and PM$_{10}$ levels were below 25 and 50 μg/m$^3$ on both sides of the bridge almost every day. These limits were exceeded only one day (5/12/2013) on the side of Antirrio (26.4 and 52.2 μg/m$^3$ for PM$_{2.5}$ and PM$_{10}$ respectively). However, during the winter period, PM$_{2.5}$ and PM$_{10}$ levels are higher due to the use of light oil and biomass burning for space heating. Pb levels were very low; the average daily value recorded (2.6 ng/m$^3$) is two orders of magnitude lower than the regulatory limit of 0.5 mg/m$^3$. Hourly average concentrations of CO, SO$_2$, NO and NO$_2$ for both sides were below the regulatory thresholds. Overall the contribution of the Charilaos Trikoupis bridge to the surrounding air pollution levels is very low. This is the result of the relatively low daily volume of vehicles (~ 10000 vehicles per day), the respective traffic fleet composition (~80% of the traffic fleet are passenger vehicles) and the speed limit (80 km/h) which does not favor traffic emissions. In addition, the strong and frequent winds further contribute to the rapid dispersion of the emitted pollutants.

INTRODUCTION

The Chariiakos Trikoupis bridge, known as Rio–Antirrio bridge, is one of the world’s longest cable-stayed bridge of multiple openings in the world, with a total length of 2,252 meters. It connects Western Greece with the rest of the country. In this study an overview of the air pollution monitoring in the area in 2013-2014 is presented. This is part of the annual environmental impact assessment of the bridge operation that our laboratory is responsible for on behalf of the Ministry of Development. The project concept is in compliance with the general obligations of the Ministry of Development, according to the approved environmental regulations in the area of Rio – Antirrio.

Residents of these communities which are in close proximity to major trade corridor are potentially exposed to increased commercial traffic pollution. Diesel exhaust has been observed to cause changes in lung function and other respiratory symptoms as well as being identified as a probable human carcinogen [1]. This study seeks to examine the contribution of diesel trucks and vehicles traffic across Charilaos Trikoupis bridge to geographical distribution of air pollution in the area of study. The dispersion and dilution of air pollutants emitted by vehicles is one of the most investigated topics within urban meteorology.

Air pollution is frequently started reason for spatial measures aimed at controlling motor vehicles. Such measures are often conducted in order to determine whether the levels of air pollutants from motorways affect the public health [2]. This creates a certain pressure to measure the true social cost of the construction of large infrastructures [3]. The cost of air pollution, noise and other environmental damage are not precisely measurable.
Nevertheless estimation of pollution cost from motor vehicles can help shape the broad outlines of policy towards pollution control. This study provides an extensive field evidence of the impact of a Charilaos Trikoupis bridge, one of the world’s longest bridge, on the local environment and the nearby community.

The measurements focused on pollutants that are most commonly measured and regulated, namely CO, NO, NOx, SO2, and PM10 and PM2.5. Only few studies were conducted on the field monitoring of air pollution near bridges which connect major motorways. In 2012 a monitoring campaign was design in order to assess changes in local air quality resulting of the Peace Bridge Plaza, located in the City of Buffalo, US–Canadian border crossing point. A wide range of pollutants, including UFPs, organic and inorganic pollutants, were sampled at different fixed sites upwind and downwind of the Peace Bridge plaza. Brief descriptions of concentrations measured at each of the fixed sampling sites and the relative differences among sampling locations and campaigns, and between weekend and weekday values and day and night values, were provided [4]. Across the two winter sampling sessions and one summer session, the 12-hour daily PM10 mean concentrations at the both sides of the bridge (Chapel, School, and GLC) were 23.8 μg/m³, 22.6 μg/m³, 19.1 μg/m³, respectively. The PM2.5 means at the three sites reflected similar proportional differences 15.7 μg/m³, 14.6 μg/m³, and 13.4 μg/m³ for the sites, respectively. This indicates that on the average, there is no significant source of PM2.5 impacting the neighborhood around the Peace Bridge. However, in another study reported by Baxter [5] measurements was performed in order to examine the contribution of diesel truck traffic across Ambassador Bridge to indoor exposure patterns of EC, the importance of ventilation and wind speed, in homes in the close proximity to the bridge. The results showed that the percentage of time a home was downwind from Ambassador Bridge’s tollbooth was a significant contribution to indoor levels, whereas no association was observed with a home's distance from the bridge's tollbooth. In addition to the effect of the bridge being greater in homes with higher air exchange rates.

There is also a port near Charilaos Trikoupis bridge, on both side of Rio and Antirrio that may serve as another significant source of air pollution. This port used to be a vital link between Western Greece and the rest of the country. The daily number of ships was decreased and nowadays the daily volume of ships is 55. This lead to reduce the influence of maritime emissions contributing particularly to local air pollution [6].

The methodological framework followed herein includes systematic recording of air pollution levels in the selected locations on both sides of Rio and Antirrio, near the edges of the bridge, for selected periods of time of years 2013, 2014 and 2015. The aim of the study is to measure air pollution levels in order to estimate not only the overall current state of the environment, but also forecast of air pollutants based on future traffic load scenarios. The key element is to make reasonably accurate projections of air pollutants emissions, i.e. vehicle utilization and to investigate more stringent requirements that may be needed in order to protect public health. Moreover, this study was conducted to examine the dependence of air pollution levels upon traffic density and meteorological conditions.

**METHODOLOGY**

**Study area and monitoring equipment:** Four campaigns were realized in the course of the last two years (Table 1). The exact periods of the two annual campaigns were selected taking into account the high traffic seasons according to a careful examination of the bridge traffic patterns. With regard to PMx and TSP, samplers were installed near the edges of the bridge located in Rio and Antirrio. In particular, samplers were installed on a hotel terrace at the Rio (38°30’N; 21°78’E) sampling site. The vertical distance from the hotel to the exit of the bridge is 350 meters while the vertical distance to the road which connects the hotel with the bridge is 50 meters. The hotel is located in an area where there are no roads with heavy traffic levels. The samplers at the sampling site of Antirrio (38°33’N; 21°76’E) were placed to the building of the Computer Engineering Department of the Technological Educational Institute of Western Greece and in particular on the terrace. The vertical distance from the exit of the bridge is 250 meters, while the vertical distance from the road which connects the hotel with the bridge is 130 m. In addition, the building is adjacent to the main road which connects the ferry of Antirrio with the local road.

PM mass concentration was determined on filter membranes by the gravimetric procedure as well as from the optical particle counter number concentration measurements. Parallel dynamic measurements of CO, NOx, SO2, PM2.5 and PM10 were placed indoor and their sampling lines were placed outdoors though appropriate openings in compliance with the requirements of their institutions. In each of the campaigns measurements of PM2.5, PM10 and TSP were performed continuously during 10-day periods near the edges of the bridge located in the urban areas of Rio and Antirrio. Whereas dynamic measurements of CO, NOx, SO2, PM2.5 and PM10 were operated for 5 days in Rio and then 5 days in Antirrio. PM2.5 and PM10 samples were collected using low-flow air samplers (ENCO PM, TCR TECORA, Italy). The samplers used sampling heads meeting the EN 12341 (PM10) and EN 14907 (PM2.5) standards, and operated at a flow-rate of 38 L/min, with a collection time of 24 h per sample. Samples were collected on PTFE membranes filters with PMP supporting ring (PALL Life Sciences, Ø 47mm, pore size 2 μm, USA). Teflon filters were analyzed gravimetrically for particle mass concentrations using an electronic microbalance with a sensitivity of ±1 μg after 24-h equilibration at a temperature between 20 °C and 23 °C and a relative humidity (RH) between 30 and 40%. Each filter was weighed at least three times before and after sampling, and the net mass was obtained by subtracting the average of the pre-sampling weights from the average of the post-sampling weights. Differences among replicate weightings were <5 μg for the blanks and the samples. Prior to the start of the sampling campaign, the flow rate of the PM2.5 and PM10 samplers was calibrated.
Table 1. Sampling periods of the campaigns

<table>
<thead>
<tr>
<th>Sampling Periods</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
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<tbody>
<tr>
<td>Duration of sampling</td>
<td>10 September - 20 September 2013</td>
<td>29 November - 24 December 2013</td>
<td>11 June - 21 June 2014</td>
<td>30 August - 9 September 2014</td>
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Field blank filters were also collected and used to correct for background concentrations or influences from handling and transport.

Particle number concentration was measured by means of a laser scatter optical particle counter (Osiris, Turnkey Instruments Ltd) continuously and simultaneously operating and indicating mass fractions of PM1, PM2.5 and PM10. Time duration of the sampling phase was 24 h and the time interval was 15 min.

TSP were collected on quartz filters (203 mm × 254 mm) using high-volume sampler Model Tisch. The total volume of air sampled was approximately 2000 m³. ¾ portion of the exposed filter was cut and carefully placed into teflon bottles. After that, it was digested to 95 °C for 3 hours using an extraction fluid containing 20 mL HNO₃ (6N), until the liquid evaporated up to about 10 mL, and then diluted to a final volume of 50 mL. After extraction, the solutions were filtered through 0.2 µm membrane filters. Lead concentrations were measured using an inductively coupled plasma mass spectrometer (ICP-MS).

The concentrations of other selected pollutants CO, NOₓ and SO₂ were also measured using Thermo Model 48i, 42i and 43i (all three by Thermo Fisher Scientific, Inc.). These systems rely on gas filter correlation, chemiluminescence and UV fluorescence measurement, respectively. During this study, concentration data of CO, NOₓ and SO₂ were obtained at 15 min intervals. However, these data were analyzed at varying time intervals (e.g., hourly, daily) for evaluation with different purposes. For this purpose, a moving average (rolling average or running average) is used in order to be created series of averages of different subsets of the full data set [2]. In addition, a list of meteorological parameters (wind speed and direction, temperature, humidity and cloudiness) that is needed for was provided from Hellenic National Meteorological Service (EMY).

The pollution data were analyzed statistically and the quality of the air was characterized according to the US Environmental Protection Agency indicators and the European Common Air Quality Index framework. EPA AQI [8] is an index for reporting daily air quality and for informing how clean or polluted air is, and what associated health effects might be a concern for human. The AQI focuses on health effects from exposure to polluted air after breathing within a few hours or days. European Common Air Quality Index framework was developed within the European project CITEAIR century [9] which allows us to compare air quality for different cities in different countries in real time to meet the need of comparing air pollution levels between different cities. Furthermore hourly volume of vehicles and the respective traffic fleet composition were obtained from Gefyra Litourgia S.A.

RESULTS

The results indicated that air pollution levels are in general below the regulatory thresholds. The low contribution from traffic emissions, for the 3 sampling periods, in the area is also justified by the low PM₂.₅/PM₁₀, which is on average 0.49 (sd 0.12), indicating that long range transport is more significant that local sources. However, only during the winter period, the rate of PM₂.₅/PM₁₀ was on average 0.7 (sd 0.2) indicating the elevated PM₂.₅ levels resulting of the use of light oil and biomass burning for space heating. Nevertheless, traffic emissions from the bridge are not the main source of air pollution in the area. PM₂.₅ and PM₁₀ levels were below 25 and 50 µg/m³ on both sides of the bridge almost every day. In particular, during the four periods of measurements the daily max average concentration (standard deviation, minimum, maximum) of PM₂.₅ and PM₁₀ were higher in the second period 20.57 (8.39, 10.6, 41.2) and 25.98 (10.1, 15.8, 52.2) µg/m³ respectively. At the same time, during the same period the maximum average concentration (sd, min, max) of CO, NO and NO₂ were 5.05 (0.42, 4.49, 5.78) mg/m³, 1.08 (0.69, 0.58, 3.40) and 17.95 (4.34, 11.14, 24.19) µg/m³ respectively. The daily max average concentration (sd, min, max) of CO, SO₂, NO, NO₂, PM₁₀ and PM₂.₅ during the summer periods of sampling for the side of Antirrio were 2.05 (0.06, 1.97, 2.12) mg/m³, 2.15 (0.07, 2.09, 2.16) µg/m³, 1.27 (0.23, 1.07, 1.72) µg/m³, 10.2 (1.62, 7.08, 11.67) µg/m³, 12.6 (3.31, 8.42, 19.57) and 7.03 (3.35, 1.03, 11.72) µg/m³, while for Rio the respective levels were 2.39 (0.09, 2.27, 2.49) mg/m³, 2.22 (0.08, 2.11, 2.33) µg/m³, 1.33 (0.89, 0.6, 2.8) µg/m³, 13.12 (0.68, 1.28, 14.36) µg/m³, 19.16 (6.97, 11.01, 30.79) µg/m³ and 8.95 (2.76, 5.67, 12.36) µg/m³ respectively. The higher levels of PM₂.₅ and PM₁₀ during winter were due to light oil use as well as fossil fuels and biomass burning for space heating [10].

The levels of the different PM size fractions (as well as main meteorological parameters) are illustrated in Figure 1 & 2 for the four periods of sampling, for both Rio and Antirrio sampling sites. According to Figure 2 the days characterized by high rainfall and wind speed, PM concentration is decreased. The minimum value of PM₁₀ was 8.42 µg/m³ during the 4th period and of PM₂.₅ was 3.28 µg/m³ during the 3rd period at sampling site of Antirrio. It is also observed that at the days with low temperature values, PM concentration is increased. The max daily concentration of PM₁₀ and PM₂.₅ was observed on the 14th January 2013 at the sampling site of Antirrio,
when temperature was almost 3.6°C and humidity 8.2%. While the respective value for PM$_{10}$ and PM$_{2.5}$ was observed on the 5th of January 2013 (temperature 0°C and 16.2 % precipitation) at Antirrio site. During the cold period (2nd) with the lowest temperature the concentrations of suspended particles are increased in the both sites.

Figure 1. That is the result of biomass burning as a source of heating. On the contrary, PM$_x$ concentrations tend to decrease during the transition from the cold to the warm period. It is noteworthy that on the 1st of January 2013, when the wind speed is almost 26.8 km/h and the temperature 8°C, PM$_x$ concentration values are decreased, because the fact that PM is dispersed by the wind. The strong and frequent winds further contribute to the rapid dispersion of the emitted pollutants especially, during days with high wind speed, a decrease of PM concentration is observed. The available set of data was divided into 16 main wind directions. The frequency of wind directions during the measurement period is presented in Figure 3. During the four campaigns the most frequent wind was blowing from WSW direction and the wind speed varies from 4.2 to 20.1 km/h with a maximum value during the 1st period of sampling. The average wind speed during the campaigns was 12.32 km/h. The average daily concentrations of NO$_2$, NO, CO, SO$_2$, PM$_{10}$ and PM$_{2.5}$ during prevailing wind direction are decreased. Maximal concentrations of air pollutants were connected with a local wind blowing from ENE direction.

Generally, PM concentration depends not only on rainfall and wind speed, but also on temperature. For example, when temperature increases, needs for residential heating and therefore biomass combustion are not important enough. As a result, PM concentration in the atmosphere is decreased.

Pb levels were very low; the daily max average concentration value recorded 7.9 ng/m$^3$ only one day (31/8/2014) on the side of Antirrio and the daily average concentration during the two years sampling campaigns was 1.9 ng/m$^3$ at the sampling site of Rio and 2.6 ng/m$^3$ at the site of Antirrio, which are two orders of magnitude lower than the regulatory limit of 0.5 mg/m$^3$.

ANOVA test was realized using MATLAB. The results of the analysis showed that there is not signification statistical to the different datasets of the 1st, 3rd and 4th period as the p-values were <0.05. However, the second period appeared significant statistical different (p>0.05) confirming the different and actual higher levels concentrations of PM$_{2.5}$, PM$_{10}$, CO, NO and NO$_2$ that observed during the monitoring.

Due to technical problems the 3rd period’s dataset of the NO and NO$_2$ were losted. Using Artificial neural networks (ANN) was implemented a form of competitive machine learning of the data structure and the missing dataset was generated. A neural network based on regression mechanism was applied to MALTAB® creating a training with performance that rises the levels of 75%.

The European Union has developed an extensive body of legislation which establishes health based standards and objectives, over differing periods of time taking into account that the observed health impacts associated with the various pollutants occur over different exposure times [11]. The campaign results indicated that air pollution levels in the area of Rio and Antirrio are in generally below the regulatory thresholds.

![Figure 1](image-url)
Figure 2. PM$_{10}$ and PM$_{2.5}$ daily average concentration, temperature, wind speed, rainfall for Rio and Antirrio during the 4 periods. The higher levels of PM$_{2.5}$ observed during the winter period are attributed to local sources of space heating, as well as to the lower mixing height.

Average hourly traffic load is presented in Figure 5. Despite high levels of traffic, low contribution from traffic emissions in the area, which indicates that long range transport is more significant than local sources. Moreover, during the 2nd period the amount of vehicles that crossed the bridge was the lowest level in contrast with the other periods. As it has been mentioned, during the 2nd period the concentration levels of PM$_{2.5}$, PM$_{10}$, CO, NO and NO$_2$ were higher and taken into account the traffic of this period, it is confirmed that the origin of the pollutants were from light oil use and biomass burning for space heating. Additionally, the maximum average daily concentration (sd, min, max) of Pb and SO$_2$ were observed during the fourth period and the respective levels were 2.32 (2.07, 0.8, 7.9) mg/m$^3$ and 2.22 (0.08, 2.11, 2.33) μg/m$^3$. It has to be noted that during 4th period, it was also observed the highest concentration of Pb that rise the amount of 7.9 μg/m$^3$. The higher levels of SO$_2$ reveal the fact that the buses, the trucks and the diesel vehicles have strong contribution to emissions. The bus fuel and particular diesel fuel contains S that are emitted to atmosphere as SO$_2$ and Pb from the exhaust during the fuel combustion. The trend of the SO$_2$ and Pb related to the traffic is illustrated in Figure 4 taken into account the amount of vehicles that use leaded and diesel fuel according to Hellenic Statistical Authority[12].

Figure 3 Wind frequency direction and average at the location of Rio-Antirrio bridge.
Figure 4. Period amount of vehicles crossing the bridge and daily average concentration of SO\textsubscript{2} (μg/m\textsuperscript{3}) and Pb (ng/m\textsuperscript{3})

In Figure 5 average hourly concentrations of NO\textsubscript{2}, NO, CO, SO\textsubscript{2}, PM\textsubscript{10}, PM\textsubscript{2.5} and average traffic flow are presented. The SO\textsubscript{2} concentration started to increase in the morning hours reaching a morning peak (2.3 μg/m\textsuperscript{3}) from 11:00 till noon. A gradual increase of SO\textsubscript{2} concentration was noticeable accompanied by the average hourly increase of trucks and busses. With regard to NO\textsubscript{2}, concentration started to increase in morning hours 9:00. At 12:00 measured value was about 17.6 μg/m\textsuperscript{3} reaching the peak value followed by the overall concentration decrease at 22:00 at night. The hourly variation of NO\textsubscript{2} during the day follows the same trend as the hourly variation of vehicles and motorcycles. The PM\textsubscript{10} and PM\textsubscript{2.5} concentration had minimal value in early morning hours (18.7 and 14.6 μg/m\textsuperscript{3}, respectively) then, increased and remained almost unchanged from 12:00 till noon. An increase followed and a peak value occurred at 21:00 36.4 μg/m\textsuperscript{3} for PM\textsubscript{10} and 25.5 μg/m\textsuperscript{3} for PM\textsubscript{2.5}. Regarding CO concentration increased around sunrise reaching the maximal value between 8:00 and 9:00 (2.1 mg/m\textsuperscript{3}). A slight decrease of CO concentration was observed between 16:00 till 20:00. The CO concentration than started to increase at about 21:00 (2 mg/m\textsuperscript{3}).

Figure 5. Hourly average concentrations for all pollutants for all periods and traffic flow.
The AIP pollution data was also characterized according to the United State (US) Environmental Protection Agency (EPA) indicators and the Common Air Quality Index framework. EPA AQI is an index for reporting daily air quality and provide a characterization of how clean or polluted is the air, and what associated health effects might be a concern for human. In particular, the AQI focuses on health effects under of few hours or daily exposure on breathing polluted air [13]. The US EPA indicator was calculated according to the rules of the EPA by linear interpolation between the 6 class borders:

\[
AQI_p = \frac{I_H - I_L}{BP_H - BP_L} (C_p - BP_L) + I_L
\]

Where AQI_p is the index for pollutant p, C_p is the concentration (daily synthesis) of the pollutant p, BP_H is the breakpoint C_p, IH is the AQI value corresponding to BP_H, IL is the AQI value corresponding to BP_L. The largest or dominant AQI_p obtains to evaluate the air. Additionally, the Common Air Quality Indicator (CQAI) [9] is inspired by EU legislation. The calculation is released by linear interpolation between the class borders for NO2, CO, PM10 and PM2.5.

The US EPA AQI was calculated for NO2, PM2.5 and PM10 and the result showed that the dominant pollutant in Rio-Antirrio Bridge was PM2.5 at both locations. Error! Reference source not found. illustrates that during the 4 periods of measurements the daily air pollution was characterized as “moderate” with 21% and 12% for the Rio and Antirrio, respectively. But it has to be noted that the 87% of these measurements was observed the winter period (2nd period). Simultaneously, CQAI showed that in Rio and Antirrio PM2.5 was also again the dominant pollutant. It was highlighted that the 2% of the measurement was at level of the high pollution and this percentage was observed then. That could be related to the relative increase in all-size fraction of PM emissions in Greece, especially during the cold months of the year due to biomass combustion for space heating [15]. Yet, the results of the AQI calculations indicate that care has to be taken to cater to the needs of susceptible individuals.

CONCLUSIONS
Under the framework of the annual environmental impact assessment of the bridge operation and after 4 periods of a systematic daily monitoring of the air pollutants PM2.5, PM10, CO, SO2, NO, NO2 and Pb a large pool of data was created and was analyzed statistically. The quality of the air is characterized according to the US Environmental Protection Agency indicators as “good” and “moderated “ as well as according to the European Common Air Quality has mainly “very low” and “low” pollution levels.
The dispersion and dilution of air pollutants emitted by vehicles is one of the most investigated topics within urban meteorology. Overall the contribution of the Charilaos Trikoupis bridge to the surrounding air pollution levels is very low. This is the result of the relatively low daily volume of vehicles (~ 10000 vehicles per day (sd is ~1350)), the respective traffic fleet composition (~80% of the traffic fleet are passenger vehicles) and the speed limit (80 km/h) which does not favor traffic emissions. In addition, the strong and frequent winds further contribute to the rapid dispersion of the emitted pollutants. Although the lower level of traffic during the winter it was observed higher levels of PM that was attributed to local sources of space heating, as well as to the lower mixing height. Moreover the residential heating emissions were increased due to the introduction of biomass as a fuel widely used in Greek cities for space heating due to economic crisis.

Further work is expected on developing and using sufficient and reliable computational models in order to be assessed the environmental impact of the bridge aiming to inform and influence decision-making as well to forecast of air pollutants based on future traffic load scenarios. Moreover, a health impact assessment will be realized as it has been observed that diesel exhaust cause changes in lung function as well as being identified as a probable human carcinogen.

Rio-Antirrio bridge and its surroundings have to stay under continuous and uninterrupted controls and monitoring in order to ensure compliance with environmental legislation and standards as well as examine the health and environmental impact of the bridge operation. The results of our measurements did not cause any concern; however, preventive mitigation actions need to have been scheduled and operational plans for their execution must have been drawn in order to ensure long-term environmental sustainability.

REFERENCES