

## MEASUREMENTS OF AIR QUALITY IN THE PORT OF PATRAS GREECE AND IN MORE REMOTE AREAS

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### ABSTRACT

Air pollution affects the public health, natural ecosystems and brings changes in climatic conditions. The problem of air pollution is mostly marked in urban areas, where the accumulation of human activities lead to an increase of air pollution. Ports are main sources of air pollution in nearby cities.

Ship emissions derived from the combustion of petroleum products contain harmful organic and inorganic substances that remain in air for a long time. Under certain meteorological conditions human beings via respiratory and other systems can take them up. As a result of this, respiratory inflammations and neurological problems, cancer even death are caused.

For this reason it is very important to study the air pollution caused by emissions from ships.

In this work, the variability of particle concentrations in the air, in relation to ship's arrivals and departure is studied. The aim of this work is to compare the results of particle measurements derived from ship emissions in regions close to port relative to those from remote areas. For this reason measurements were obtained from the top of buildings, very close to the port, and at a distance from the port. For this purpose measurements of particle concentration in the air were carried out, using Ultra fine Condensation Particle Counter (Model A3025A).

**Keywords:** Port, quality of air, ship emissions.

### 1. Introduction

During the last years the air pollution problems became more obvious. It is evident, that in cities with ports huge amounts of soot derived from ships diffuse into the city, being an important environmental problem (Apostolopoulou K. and Varnavas S.P., 2011, 2013). Epidemiological studies have consistently shown an association between particulate air pollution and not only exacerbations of illness in people with respiratory disease but also rise in the numbers of deaths from cardiovascular and respiratory disease among older people (Seaton A., Godden D., MacNee W, Donaldson, 1995).

The aim of this work is the investigation of the impact of maritime transport on the quality of the air around the port of Patras, Greece. Particle measurements and of air quality determinations were made in regions close to port relative to an area at some distance from the port.

### 2. Methodology

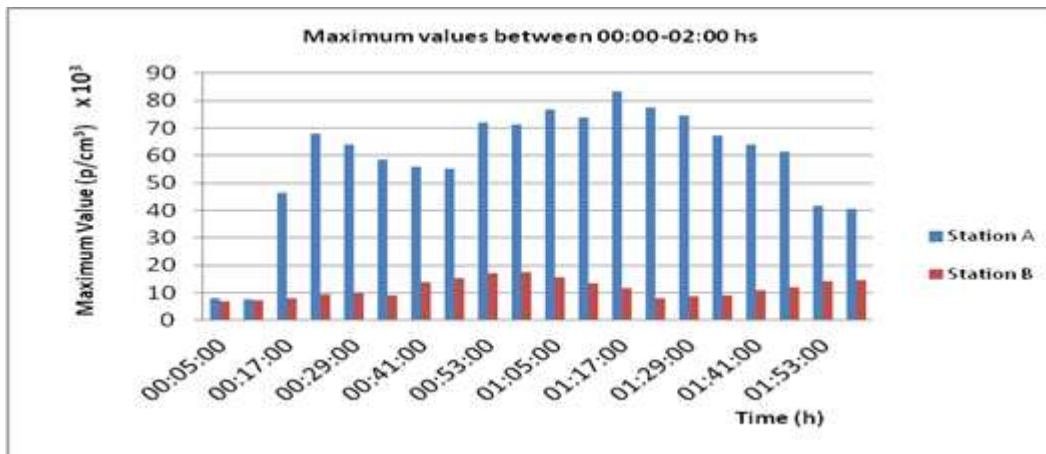
The variability of particulate concentrations in the air was studied, using an Ultra fine Condensation Particle Counter (Model3025A). Measurements were obtained from the top of buildings very close to the port, and at a second station 2km from the port. The range of particle concentration detection varies from less than 0.01 particles/cm<sup>3</sup> to 9.99x10<sup>4</sup> particles/cm<sup>3</sup> with the time of the recording of the measurement being 5 min (Apostolopoulou K. and Varnavas S.P., 2011, 2013).

### 3. Results and discussion

This work compares the particle concentration levels in air in two regions of Patras city. Measurements at one station, named here 'Station A', were obtained from the top of a building,

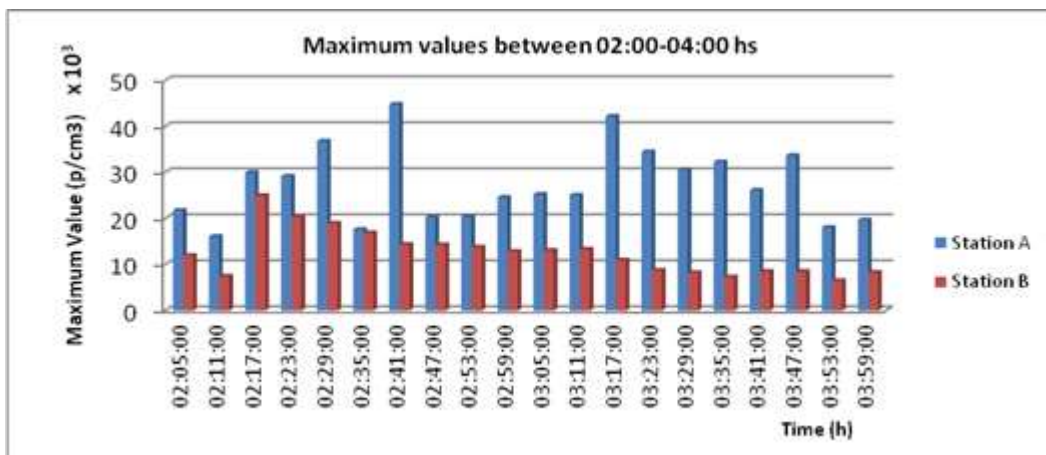
very close to the port. The second station, named 'Station B', is located at the top of building at 2km from the port. Measurements were taken during the whole day. A representative description of concentration levels of particles in the air for 'Station A' is given on Monday 18<sup>th</sup> August 2008. Measurements for 'Station B' are given on Monday 25<sup>th</sup> August 2008. During these days the arrival and departure schedule of the ships were similar. Diagrams show the maximum recorded values during measuring time.

As it is seen in the diagram below (Figure1) the maximum particle concentrations in air at the port (Station A) between 00:00 h and 02:00 h vary between  $7.40 \times 10^3$  and  $83.2 \times 10^3$ . At station B, the maximum particle concentrations in air vary between  $7.08 \times 10^3$  and  $17.7 \times 10^3$  p/cm<sup>3</sup>.



**Figure1:** Maximum values during measuring time 00:00- 02:00 hs, at Station A and Station B.

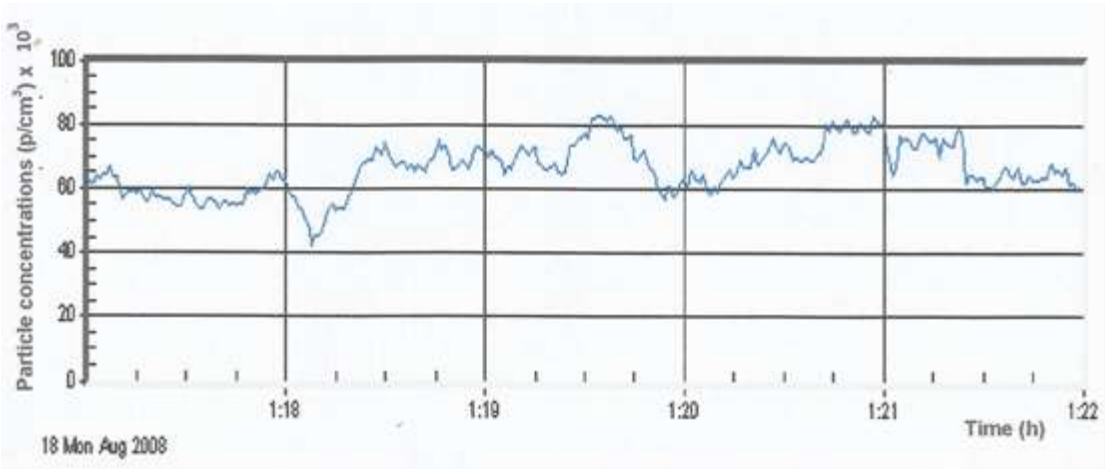
At the next period, the maximum particle concentrations in air at station A, between 02:00 h and 04:00 h vary between  $1.61 \times 10^3$  and  $44.8 \times 10^3$ . At station B, the maximum particle concentrations in air vary between  $6.52 \times 10^3$  and  $25.0 \times 10^3$  p/cm<sup>3</sup> (Fig.3).



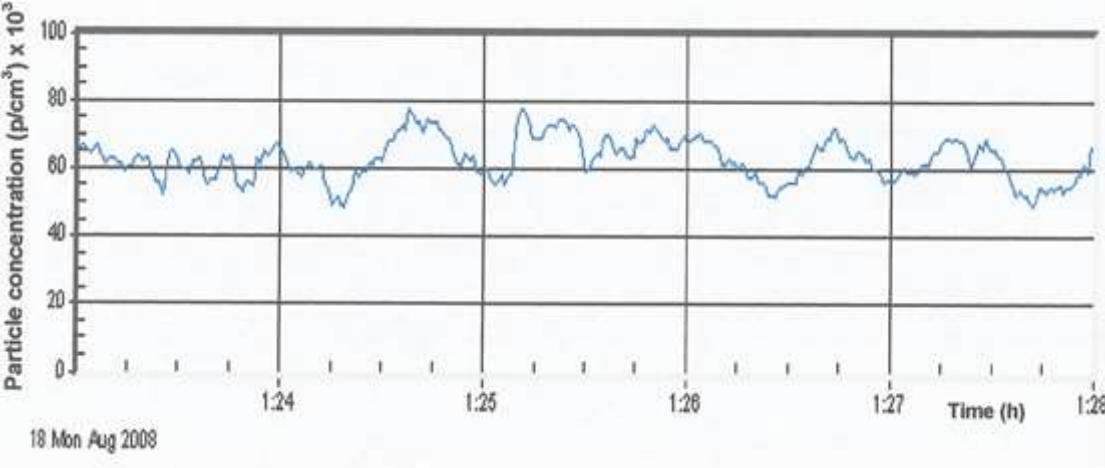
**Figure2:** Maximum values during measuring time 02:00-04:00 hs, at Station A and Station B.

It is noted that between 00:00 h and 04:00 h the maximum values of the whole period were observed between 00:20 h and 01:41 h for the Station A. The maximum value is observed at 01:17 h ( $83.2 \times 10^3$  p/cm<sup>3</sup>). Examining the arrival and departure schedule of the ships during this period it is seen that there was one arrival and one departure in the port of Patras. It is known that 20 minutes before and after anchoring time, the ship engines work at their highest power in order to achieve the necessary movements to reach the exact site of anchoring. As a result of this, large quantities of ash particles resulted from the inadequate combustion of the fuel are released in the atmosphere.

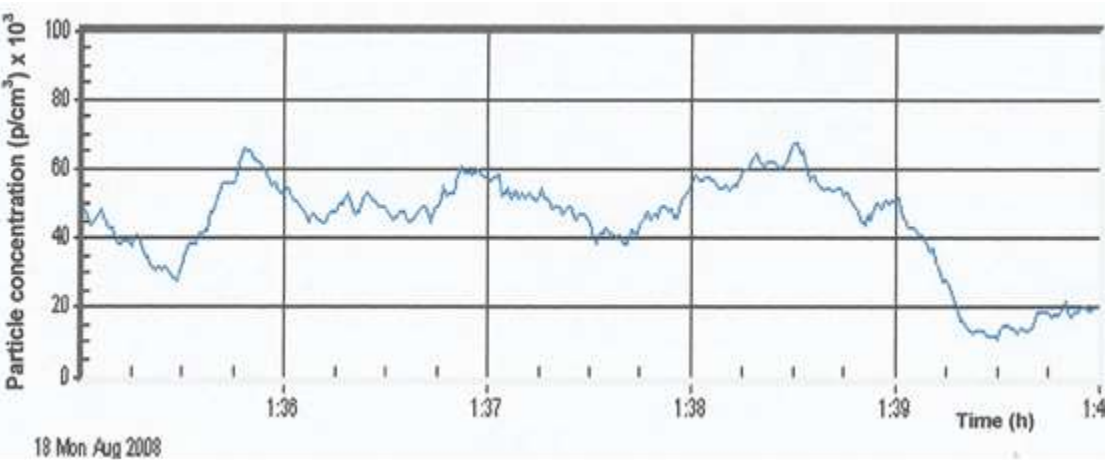
As it is seen in the diagram below (Figure3) a peak was observed at the arrival time of a ship at 01:20h. The particle concentration values increase and remain at high levels for a long time (Fig.4), (Fig.5). In fact, this is because the ship continues to operate the machines and emits particles.



**Figure3:** Variability of particle concentrations in air during the period: 01:17 h – 01:22 h on 18.8.2008. (Station A.)



**Figure4:** Variability of particle concentrations in air during the period: 01:23 h – 01:28 h on 18.8.2008. (Station A.)



**Figure5:** Variability of particle concentrations in air during the period: 01:35 h – 01:40 h on 18.8.2008. (Station A.)

The figures below (Figs.6, 7, 8, 9, 10,11) show representative diagrams with the variability in particle levels at the next hours of the day.

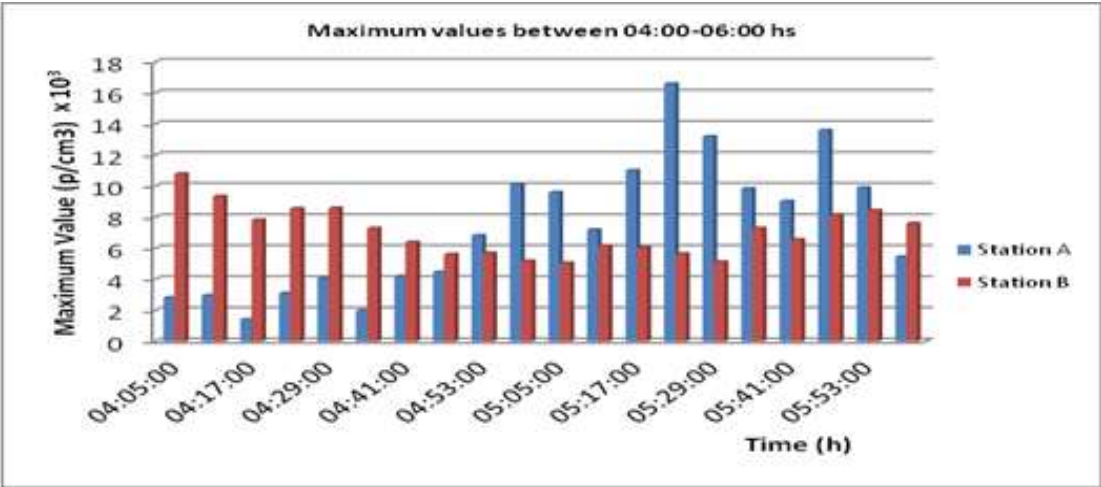


Figure6: Maximum values during measuring time 04:00-06:00 hs, at Station A and Station B.

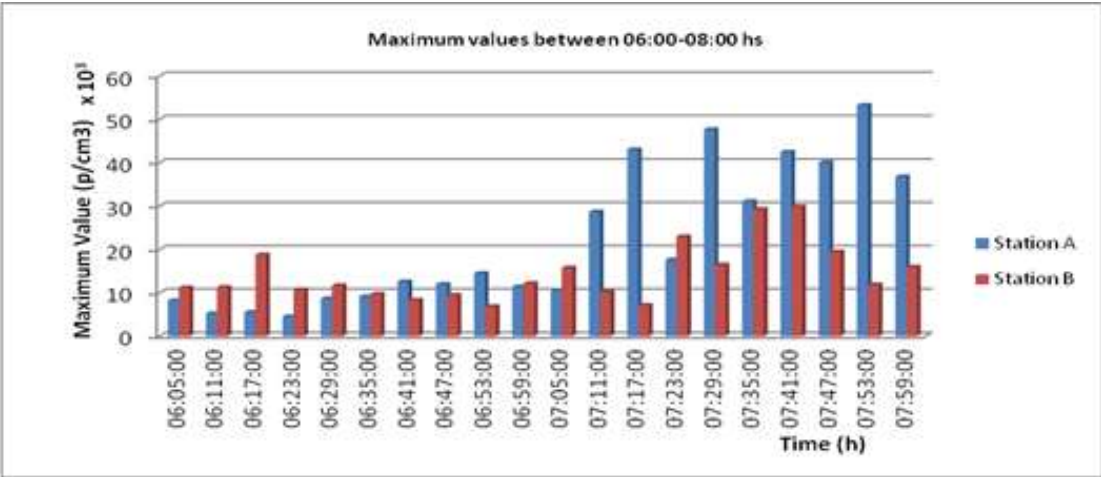


Figure7: Maximum values during measuring time 06:00-08:00 hs, at Station A and Station B.

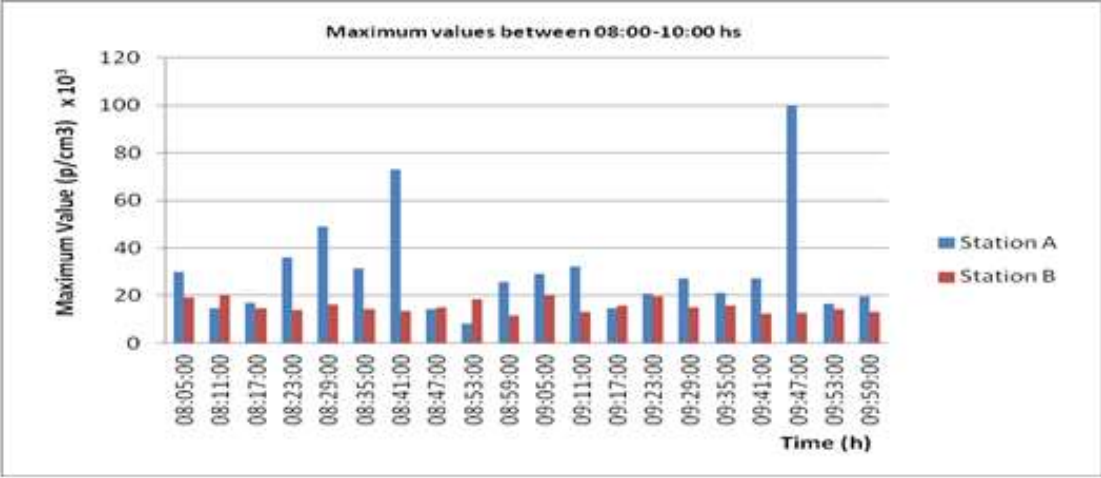


Figure8: Maximum values during measuring time 08:00-10:00 hs, at Station A and Station B.



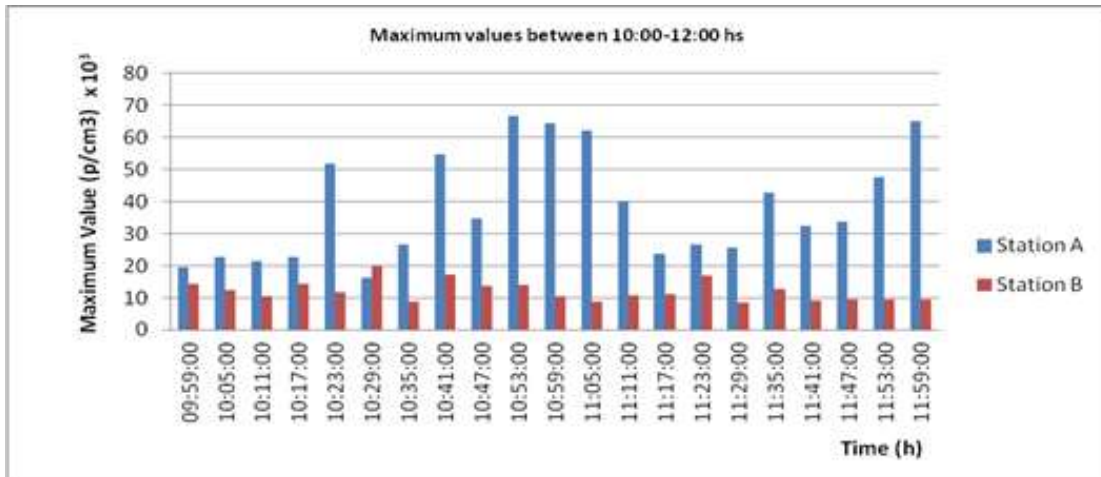


Figure9: Maximum values during measuring time 10:00-12:00 hs, at Station A and Station B.

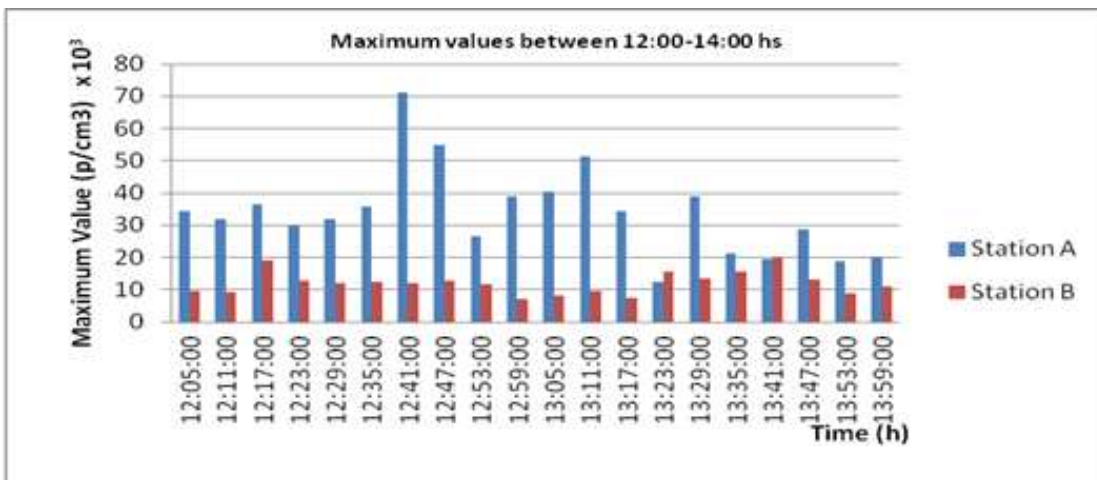


Figure10: Maximum values during measuring time 12:00-13:00 hs, at Station A and Station B.

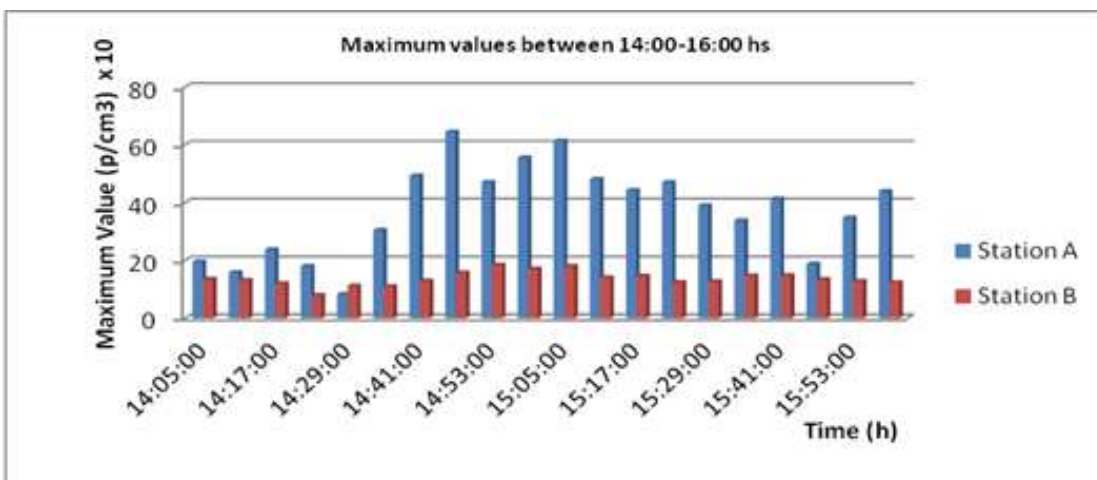
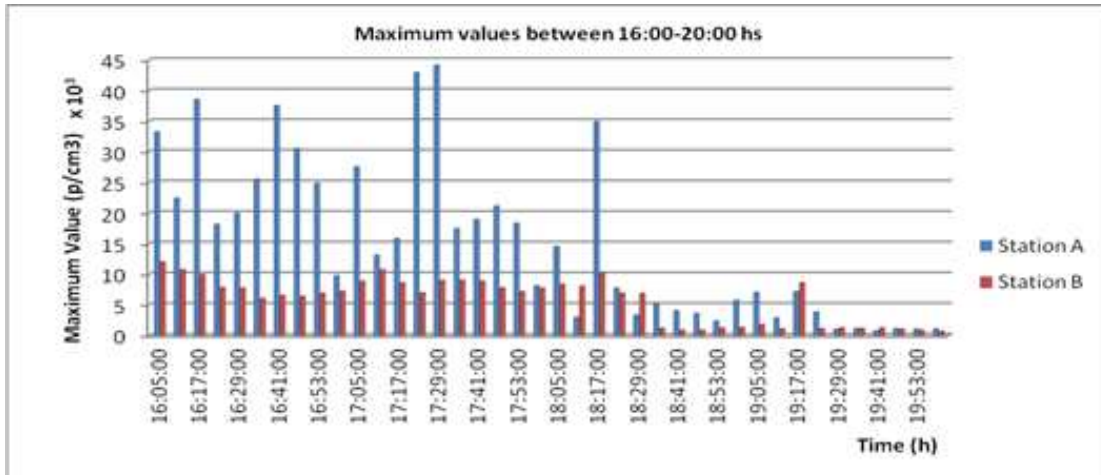


Figure11: Maximum values during measuring time 14:00-16:00 hs, at Station A and Station B.

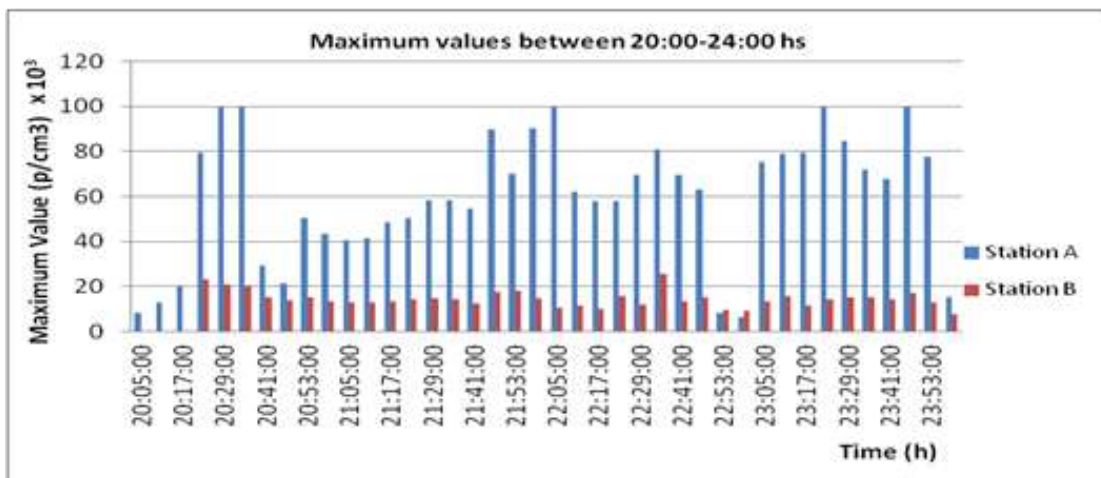
A similar situation occurs in the afternoon hours. It is noted that between 16:00 h and 20:00 h there was one arrival and one departure in the port. During the period 18:30 h to 20:17 h there was no intense activity in the port. The maximum values were observed at 17:23 h ( $42.9 \times 10^3$  p/cm<sup>3</sup>) and at 17:29 h ( $44.1 \times 10^3$  p/cm<sup>3</sup>) (Fig.12).

The variability of particle concentration in air during 18:30 h to 20:17 h, remained at low levels varying from  $0.7 \times 10^3$  to  $20.4 \times 10^3$  p/cm<sup>3</sup> for Station A, and from 0 to  $8.6 \times 10^3$  p/cm<sup>3</sup> for Station B (Figs.12,13).



**Figure12:** Maximum values during measuring time 16:00-20:00 hs, at Station A and Station B.

The variability of particle concentration in air during 20:53 h to 24:00 h, at Station A, was at very high levels ( $40.0 \times 10^3$  to  $99.9 \times 10^3$  p/cm<sup>3</sup>). According to the arrival and departure schedule of the ships, during this period there was an arrival at 21:40 h, a departure at 22:05 h and another arrival at 23:30 h of ships in the port (Fig.13).



**Figure13:** Maximum values during measuring time 20:00-24:00 hs, at Station A and Station B.

The above data show that during most of the day the particle concentration levels at Station A, remain in high levels. These high values were also a result of the wind direction, moving the particles towards the measurement station. The data is evaluated in relation to a number of factors, including the existing meteorological conditions. Except for this, the data show that during the whole day, the values of particle concentration in air at Station B, was lower than at Station A.

#### 4. Conclusions

In this work, the variability of particle concentrations in the air, in relation to ship's arrivals and departure is studied. In this work a comparison is made of the results of particle measurements derived from ship emissions in the area close to the port relative to those from remote areas.

A distinct impact of the maritime transport in the Port of Patras was demonstrated which is expressed on the quality of the air. The particle concentrations in the air during the periods that the ships are in the anchoring process reach high levels.

At the station located in a more remote area the values of particle concentration in the air was very low and about half of those recorded from the station at the port. This means that the port is a main source of air pollution in the town of Patras.

It is therefore concluded that the port is a major source of air pollution in the city, especially during the summer months, during which a considerable number of ships enter the port. Additionally, it is observed that under certain meteorological conditions, usually during the summer, a 'smoke cloud' is formed which is defused in the city transferring particles derived from the ship stacks.

## ACKNOWLEDGEMENTS

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