

# Statistical investigations on PAH concentrations at industrial sampling site

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**Abstract:** Human exposure to combustion emissions including the associated airborne fine particles and mutagenic constituents have been studied in populations in different countries. PAH compounds are generated by combustion of organic matter in mobile sources as well as in stationary sources; they play a major role in defining the overall toxicity of atmospheric particulate matter (PM) although they are negligible in the total mass of the PM. The aim of this work was to apply statistical investigations on PAH concentrations measured at industrial sampling site in Taranto (Apulia Region, South of Italy) from May 2009 to May 2010. These data, related to gaseous pollutants at different meteorological conditions, allowed to determine the relationships between industrial emissions and ambient concentrations at receptor site.

**Keywords:** PAHs, industrial site, emission sources

## 1. Introduction

Several epidemiological studies suggested the relevant role of ambient Particulate Matter (PM) in contributing to a range of health effects: the increased risk of death has been associated to the exposure to high PM concentrations, especially to the finer particles (Nadadur et al., 2009). In particular, it was found that the finer particles (PM<sub>2.5</sub>) can transport the pollutants deeply into the lung and cause many kind of reactions which include oxidative stress, local pulmonary and systemic inflammatory responses (Englert, 2004; Forbes et al, 2009). Particulate Matter consists of major components representing the main part of the total mass of particles and trace components usually representing less than 1% of total particle mass. Among the PM trace components, Polycyclic Aromatic Hydrocarbons (PAHs) constitute a major class of environmental pollutants. Many PAHs, particularly the larger five- and six-ring compounds that can be metabolized to diol epoxides, are mutagens and carcinogens (Binkova et al. 2007; de Kok et al. 2006). The primary source of PAH compounds in air pollution is from combustion of fossil fuels (e.g., coal, oil, gasoline and diesel fuel), vegetative matter (e.g., wood, tobacco, paper products, and biomass) and synthetic chemicals (e.g., from plastics and other chemical products in incinerated municipal, hospital and hazardous wastes). Once released in atmosphere, PAHs are subjected to

several atmospheric processes; heterogeneous reactions (photo-oxidations) and gas-particle partitioning are the main transformations processes of PAHs. These processes are dependent on the different meteorological conditions. The aim of this work was to assess the effects of emission sources on particle-bound PAH concentrations determined at the sampling site in Taranto from May 2009 to May 2010. These data were linked to meteorological conditions and gaseous pollutants measured at the monitoring station (NO<sub>x</sub>, CO, BTX). Finally, Principal Component Analysis (PCA) was applied to the dataset in order to provide information on the most relevant emission sources located in the area under investigation.

## 2. Materials and Methods

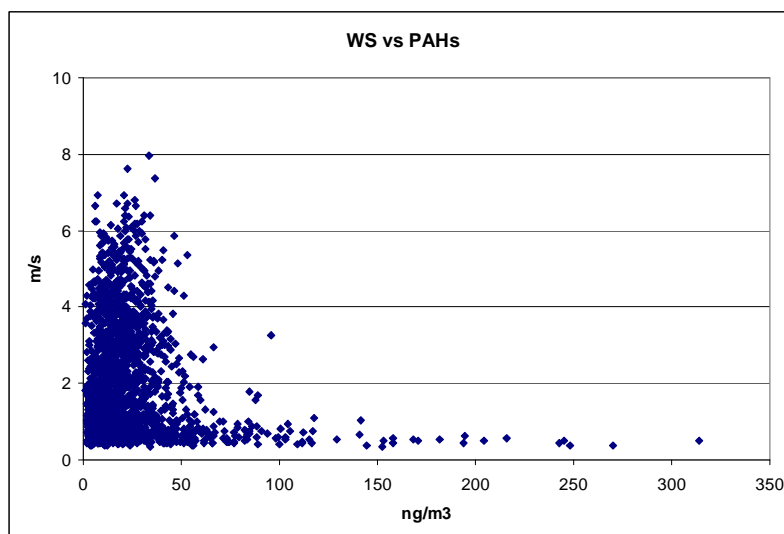
The sampling site is located in Taranto (Apulia Region, South of Italy), close to the industrial area (Via Machiavelli, Tamburi district). The sampling station is a customised monitoring unit containing a range of real-time instruments for particulate matter and gaseous pollutants. It includes a PM<sub>10</sub> analyzer (SWAM Monitor), a nitrogen oxides (NO<sub>x</sub>) analyzer (API200A), a carbon monoxide (CO) analyzer (API300), a benzene-toluene-xylene (BTX analyzer) (Syntech Spectras) and a particle-bound PAHs analyzer (EcoChem PAS 2000). Meteorological data (wind direction, wind speed, air temperature, rainfall, barometric pressure and solar irradiation) are continuously recorded by an automated weather station.

Principal Component Analysis (PCA) was applied to the pollutant concentrations determined at the sampling site in order to obtain information on the characteristics of the most relevant emission sources located in the area.

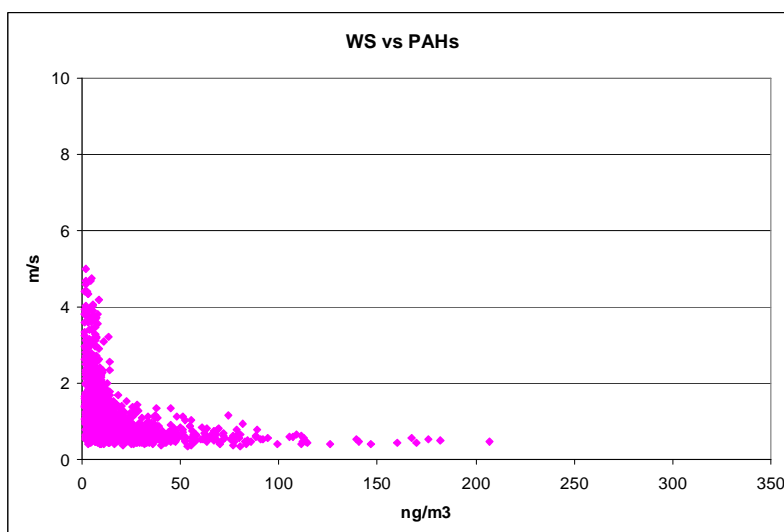
## 3. Results

PAHs data collected from May 2009 to May 2010 were related to meteorological conditions, in particular to wind speed and direction determined at the sampling site. The higher PAHs concentrations were observed for air masses coming from North-East and North-West (Sector I, 0° - 60° (North) e 300°-360° (North)) directions because of the presence of the industrial area. As shown by previous studies at the same sampling site (Amodio et al., 2009), the days characterized by gust from North or by calm wind conditions coincided with the maxima PAHs values. Therefore, the data collected in the investigated period were related to wind speed for the higher concentration direction (Sector I, 0° - 60° (North) e 300°-360° (North)) and for the other ones (Sector II, 60° - 180° (North); Sector III, 180° - 300° (North)). As shown in Figure 1, the higher PAHs concentrations were found for air masses coming from the North (Sector II), even when high wind speed is determined at the sampling site. However, as concern Sector II, lower PAHs concentrations than those previously observed can be measured at receptor site when air masses come from East direction. It was also found that the most significant values for PAHs were observed when calm wind conditions occurred, maybe due to low dispersion capacity of the pollutants in the atmosphere. Finally, the analysis of data collected in Sector III (180° - 300° (North)) (data not shown) showed the similar trend of those in Figure 2; some additional high events of pollutant concentrations were

determined for air masses come from West - North West direction, as observed for 'high polluted' direction.



**Figure 1:** Sector I, wind speed (m/s) versus PAHs concentrations ( $\text{ng/m}^3$ )



**Figure 2:** Sector II, wind speed (m/s) versus PAHs concentrations ( $\text{ng/m}^3$ )

Principal Component Analysis with Varimax normalized rotation was applied on the data matrix of hourly mean concentrations of nitrogen oxides ( $\text{NO}_x$ ), carbon monoxide (CO), benzene (B), toluene (T) and total PAHs. Since the variables were characterized by different orders of magnitude, PCA was applied to normalized data matrix. Loadings and percentage of explained variance obtained for each of the components are shown in Table 1; only variables with factor loadings greater than 0.3 are shown. Two PCs, explaining up to 80% of the total variance of data, were evaluated. The PC1, which explained the most of the variance of the data, is characterized by high loadings for all the considered parameters, except of benzene (PC2). It was explained with the closeness of the monitoring station to the industrial area, that significantly affect the pollutant

concentrations measured at the receptor. In fact, the same results in PCs, loading and explained variable (data not shown) were obtained when the PCA was performed to the dataset containing the samples collected in Sector I.

	Loadings	
	1	2
NOx	0.93	
CO	0.79	0.35
BENZENE		0.97
TOLUENE	0.66	
PAHs	0.94	
% Var	56.97	23.39

**Table 1:** Loadings, eigenvalues and percentage of explained variance obtained in PCA on data collected in Taranto sampling site

#### 4. Concluding remarks

This work was performed on data collected at Taranto sampling site (Via Machiavelli, Tamburi district) from May 2009 to May 2010. It allowed to highlight the relevance of the industrial area closed to the receptor site, that caused high pollution events when the air masses flow from the North. The same results were obtained by taking into account Principal Component Analysis performed on the dataset.

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