

Polycyclic Aromatic Compounds, 25: 1–18, 2005
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ISSN: 1040-6638 print / 1563-5333 online
DOI: 10.1080/10406630500227262



5 **LEAVES OF *NERIUM OLEANDER* L. AS
BIOACCUMULATORS OF POLYCYCLIC
AROMATIC HYDROCARBONS (PAH) IN THE
AIR OF PALERMO (ITALY): EXTRACTION
AND GC-MS ANALYSIS, DISTRIBUTION AND
SOURCES**

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15 *Polycyclic Aromatic Hydrocarbons (PAH) were determined
in the leaves of *Nerium oleander* L. an evergreen plant that
occurs widely in both urban and rural areas, to monitor the
degree of pollution in the urban area of Palermo (Italy)
compared to remote areas. Twenty sites (urban roadside,
urban, urban park, suburban and rural) in and around
Palermo city were investigated.*

20 *The purpose of this research was to investigate
concentration levels and distribution patterns and relate
them to possible sources. Analysis of 19 PAH was
performed by gas chromatography/mass spectrometry
(GCMS) using selected ion monitoring (SIM). The total
amount of PAH ranged from 10 to 166 µg/Kg d.w.*

25 *Each source gives rise to a characteristic PAH pattern, and
it is therefore possible to get access to the processes that
generate the compounds. To this aim, the recommended as
priority pollutants by the Environmental Protection Agency
(EPA), perylene and three additional alkylated compounds
30 were analyzed.*

Received ; accepted .

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Positive correlations were found between total PAH content of the leaves with CO, benzene and particulate levels measured in air of Palermo.

Keywords biomonitoring, leaves, oleander, polycyclic aromatic hydrocarbons

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INTRODUCTION

Polycyclic aromatic hydrocarbons (PAH) are molecules of great interest because of their carcinogenic, teratogenic and toxic properties. A case in point, the PAH benzo[a]pyrene is referred to as one of the most potent carcinogens known (1, 2).

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The presence and distribution of PAH in the environment is largely a product of the incomplete combustion of organic materials (petroleum, oil, coal, wood, biomasses, etc.) and PAH are present in considerable quantities in fossil fuels, from which they are released by a variety of combustion processes. A very small percentage of the PAH in the environment can be linked to natural causes, such as volcanic activity and forest fires. Anthropogenic sources such as vehicles, heating and power plants, industrial processes and refuse and open burning are considered to be the principal environmental sources (3, 4).

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In very low concentrations, they can be found in water, in soil, in sediments, in the atmosphere, in the tissues of many plants and animals and even in many foods (5–9). There are numerous references in literature concerning the PAH concentration in the atmosphere of large urban centers and of zones particularly exposed to this type of emissions (10). PAH are associated with PM_{2.5} (11,12) and increase the potential health impact of these particles. Direct correlation between the amount of PM_{2.5} in the air and human health has been shown (13).

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Their widespread distribution means that everyone is unwittingly exposed to the action of this class of substances, in working environments, in the home and in the open air.

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PAH are removed from the atmosphere both in the vapor-phase and condensed form, adsorbed to aerosol particles, and deposited in water, soil and plant foliage. In general the lighter, less hydrophobic PAH are dispersed into the environment at greater distances than heavier more hydrophobic PAH (14). PAH are essentially unavailable for uptake by plant roots (15). Smith (16) suggested that smaller leaves have higher ability to accumulate and retain particles than bigger ones (16). Simonich and Hites (17) referred to the lipid content of vegetation as a measure of the total capacity for sorption of lipophilic semi-volatile organic compounds

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70 to vegetation. Leaves with trichomes had a significantly higher total PAH concentration than hairless leaves (18).

Accumulation of PAH in vegetation depends on the properties of the particular PAH as well as on the properties of the accumulating surface (19–21) and on environmental conditions.

75 In general, for PAH, the more volatile 2- and 3-ring compounds exist primarily in the gas phase of the atmosphere, and will tend to be deposited to the plants via dry gaseous and/or wet deposition. The less volatile 5- and 6-ring PAH are more likely to be deposited on the plant surface bound to particles in wet and dry deposition. For compounds of
80 intermediate vapor pressure (4-ring PAH, for example), a temperature-dependent gas/particle partitioning of PAH will occur, such as that they are subject to both wet and dry deposition in gaseous and particle-bound form. Physiological features of leaves play an important role in determining the scavenging efficiency and retention of airborne particles on
85 the leaves. Leaf surfaces vary greatly between plant species, both in morphology and chemistry of the waxy cuticle, the number and distribution of stomata, and the presence or absence of hairs. The water repellence of leaves is important in determining how effectively the leaves can lose the particulate on their surface (22).

90 There are a number of highly dependable analytical tools (23, 24) to evaluate concentration of PAH in different environmental matrices. These, however, require the use of particularly complex—though more or less automated—instruments.

The advantages of use of animals and plants to value environmental
95 quality are reported in other articles (25, 26), in particular the leaves, the fruits of many plants and lichens have already been used to monitor air quality (27–29). The leaves of *Nerium oleander* have been chosen because this plant is widespread in the Mediterranean area and it is commonly found both in the metropolitan and in the peripheral areas of
100 the city of Palermo.

The leaves of *oleander*, with their hydrophobic chemical nature, are well equipped to accumulate PAH, as has already been demonstrated with other leaves with a waxy pericarp.

This article describes the most significant results concerning the chemical determination of PAH in *Nerium Oleander* leaves prevalently collected in the Palermo area and their possible origins. We measured PAH concentrations in the leaves with the aim of using as a bioaccumulator of the considered class of compounds and of monitoring environmental pollution in urban and suburban sites.
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110 Identification and quantification of PAH in environmental samples is often complicated by a number of other compounds present in the sample.

To avoid these problems, the GC-MS method was applied since here it is possible to identify the different compounds with the aid of spectra libraries. Samples were analyzed for 19 PAH, much of which have been listed as priority pollutants by World Health Organization (WHO), the European Economic Community (EEC) and the U.S. Environmental Protection Agency (USEPA) (30), perylene and three additional alkylated compounds were analyzed. 115

MATERIALS AND METHODS

Nerium oleander L. is an evergreen sclerophyllous shrub forming clumps up to 6 m tall and usually occurs with a spread of 2.5–4.5 m. In the wild, it grows on well drained soils, open areas, along dry water courses and ravines on both coastal and inland areas from sea level to 800 m. As an introduced species, it grows in gardens and also is popular as an urban ornamental plant all through south and insular Italy. 120 125

Chemicals

All chemicals used were of analytical grade with high purity. In particular, dichloromethane from Fluka was 99.8% purity. Sodium sulphate from Carlo Erba (Milano, Italia) was cleaned by Soxhlet extraction for 24 h with dichloromethane. Standard PAH mixture (EPA 610 PAH mix, lot LA-96245) and perdeuterated internal standards (fortification solution B Lot N° LA-92479) were from Supelco. 130

Study Area

The city has about 800,000 inhabitants. Potential sources of pollution are limited to vehicle traffic, private heating, and small-scale industries. The overall number of vehicles circulating in Palermo has been calculated at 438,000 (1999 data from ACI–Automobile Club of Italy). 135

Sampling

Chemical analyses were carried out on *Nerium oleander* leaves collected in winter 2001. The sites, which were chosen for the analysis of the leaves, are indicated in Table 1. Nineteen sites are situated in different areas of Palermo affected by various types of emissions, and one, taken as reference, in the countryside around Cefalù, far from any possible source of PAH. 140 145

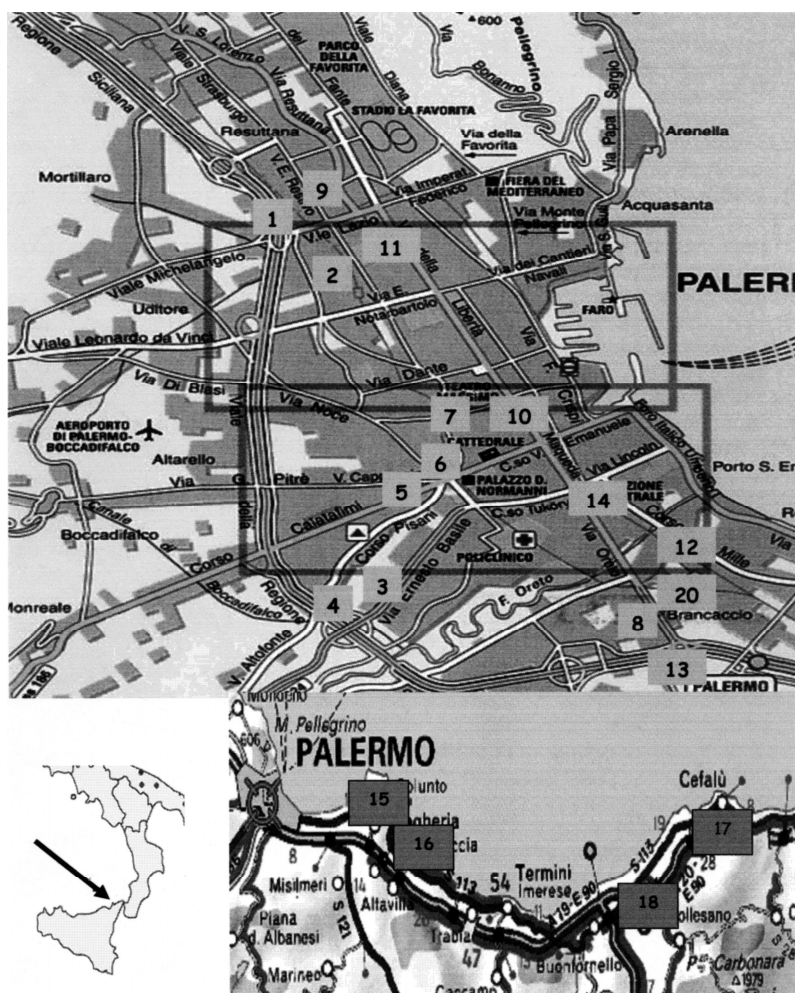


FIGURE 1. Location of sampling sites.

Between 100 and 200 g of leaves were collected from different parts of plants using rubber gloves, separated from impurities, sealed into containers and immediately refrigerated (4°C) on site, stored avoiding exposure to light, and then rapidly carried to the laboratory where they were frozen before analysis. The samples collected and used for analysis contained both young and old leaves. The repeatability of the sampling was preliminarily checked by analyzing for PAH four different samples of leaves collected on the same plant.

TABLE 1. Locations and Characteristics of Sampling Sites

Denominations	Characteristics of the sites
1. Alpi	Route frequented by very heavy and slow traffic
2. Lazio	Route frequented by very heavy and slow traffic
3. Basile	Dual carriageway frequented by very heavy traffic constituted by bus and commercial vehicles. The plant is located on median strip.
4. Department	Inside the garden of Department of Inorganic and Analytical Chemistry, 300 m away from nearest trafficked urban area
5. Indipendenza	Large square frequented by very heavy and slow traffic
6. Indipendenza 2	Large square frequented by very heavy and slow traffic
7. Court	Route frequented by very heavy and slow traffic
8. Industrial area	Large area interested by industrial activities. Located near a petroleum depot and a cast-iron foundry.
9. Alcide	Large square frequented by very heavy and slow traffic.
10. Harbor	Route frequented by heavy traffic, the sample was taken 200 m away from the harbour.
11. Leoni	Large square frequented by very heavy and slow traffic. The plants are located in a flowerbed in the median strip
12. Acqua dei Corsari	Road outside a town.
13. AGIP	Open area near a petroleum depot
14. Botanic Garden	Inside a green area interested periodically by agricultural practices 100–200 m away from traffic and 100 m away a plant from gas production
15. Aspra	Rural area. The station is located near a coast-road in particular frequented during bathing season
16. Porticello	Rural area, periodically interested by agricultural practices. The station is located in a flowerbed near a petrol pump
17. Cefalù	Rural area, distant from traffic (reference)
18. SS 113	Arterial road frequented by traffic both cars and commercial vehicles.
19. Mille	Route frequented by very heavy traffic constituted by bus and commercial vehicles.
20. Tukory	Area frequented by very heavy and slow traffic.

Extraction Procedure

Two grams of leaves were extracted during one 1 hour (3 steps of 20 min.) using an ultrasonic bath (Elma model Transonic T310, 70 W) in 40 mL of dichloromethane. The extracts were filtered through a pre-cleaned Pasteur's pipette filled with solvent-rinsed glass wool and pre-cleaned anhydrous Na₂SO₄, rinsed and concentrated in a rotary evaporator with the thermostatic bath at $T = 35 (\pm 0.5)^\circ\text{C}$. The final volume

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was around 2 ml. Finally, the solution containing PAH was taken to dry-
ness under a weak nitrogen flow. The dry residue was dissolved in 0.50
ml solution containing the following perdeuterated internal standards
in cyclohexane (0.2 mg/L each): Acenaphthene d_{10} ; Phenanthrene d_{10} ,
165 Chrysene d_{12} and Perylene d_{12} .

PAH Analysis

The qualitative and quantitative determinations were carried out by
means of a gas chromatograph (Shimadzu mod. GC-17A) coupled to a
mass spectrometer (Shimadzu, quadrupole detector mod. GCMS-
170 QP5000), operating with acquisition data (Shimadzu, CLASS 5000 sys-
tem). GC separations were achieved on an Equity-5 (30 m \times 0.25 id,
0.5 μ m) fused-silica capillary column from Supelco (Milano, Italy). The
injector mode was splitless (0.61 min) and a total flow 20.6 ml/min was
used. The injection of both extracts from samples and standard solutions
175 (1 μ l) was performed by hand. The injector temperature was maintained
at 280°C. The GC temperature program was: from 40°C (2 min) to 100°C
at 40°C/min, to 200°C at 10°C/min, to 325°C (8 min.) at 30°C/min. The
carrier gas was helium (flow rate 2.6 ml/min). The interface tempera-
ture was 325°C. The analysis was operated in Selected Ion Monitoring
180 (SIM) mode. The identification of the components of the standard mix-
ture was carried out by comparing retention times of each component
of the mixture with those of pure components, analyzed under the same
experimental conditions. Identification was confirmed by comparing the
spectra of the single components with those stored in the library of the
185 acquisition system. The identification of PAH in the solutions extracted
from sediment was carried out on the basis of previously determined re-
tention times, and it was confirmed using mass spectra. The PAH content
in the sample was quantified relative to perdeuterated PAH added to the
dry residue. The response factors of different compounds were measured
190 by injecting a mixture containing 18 standard compounds and having the
same concentration of perdeuterated PAH as that used for spiking the
sample.

Water Content Analysis

About 2 g of sample was dried at 105°C for a night. The water content
195 was determined by weight loss and was utilized to refer all the results to
dry weight.

RESULTS AND DISCUSSION

The reproducibility of sampling, preliminarily checked, is satisfactory because relative standard deviation results about 10%.

In Table 2 we report the concentration of each individual PAH detected in leaves collected in the Palermo area. The total concentrations (the averages of three analyses) of 19 compounds investigated, expressed as the sum of the concentrations, Σ PAH, varies from 10 to 166 $\mu\text{g/Kg}$ of dry matrix are shown in Figure 2. Relative standard deviation ranged from 5 to 15%.

The higher PAH concentrations have been measured in stations n° 3 (Basile), n° 4 (Department) n° 20 (Tukory), n° 11 (Leoni) and n° 10 (Harbour). The first three sites are in the same town center where the traffic is severe and slow while the fourth is located in the median strip of a square. The station n° 4, though is located in the inner garden of the Department of Inorganic and Analytical Chemistry, is influenced by proximity to traffic artery. For the station n° 3 (Harbour) the fact that concentrations of PAH are high can be attributed to its proximity to the urban center and to emission from ships, because this site is located near a commercial harbor. The content of PAH in the station n° 8 (Industrial Area) can be attributed to its proximity to the urban center and to emissions from some industrial activity. In samples from station n° 16 (Porticello) and n° 17 (Cefalù) total concentration of PAH are lower, since in this area there is practically no traffic and the anthropic activities are limited to agricultural practices.

The concentration factors, as ratio anthropized/control sites, ranged from 1.4 to 4.7 for the green areas, and from 4.7 to 19 for the roads and anthropized areas. Differences of leaves PAH concentrations between green areas and road and anthropized areas are in agreement with differences of PAH contents measured in others cities (31).

In most of the urban sampling sites, the same distribution of 19 PAH (expressed as weight percentage) is observed. Phenanthrene, Fluoranthene and Pyrene are the three most abundant components in nearly all the samples. Benz(a)anthracene was found at low concentrations in 19 of 20 sites investigated (from 0.5 up to 21.6% from total PAH). A very high concentration (45.9%) of benz(a)anthracene has been measured in the station (n° 10) located neighboring the harbor. This anomalous result can be explained by considering that environmental manmade sources of benzo(a)anthracene include diesel and aircraft turbine exhausts (31).

In this study, perylene was found at high concentrations (19.7% calculated on total PAH) only in the sample of Industrial Area. Even if perylene is not universally considered a *pyrogenic* PAH or a *petrogenic*

TABLE 2. PAH Concentrations (Average of three Analysis Expressed in $\mu\text{g/Kg d.w.}$) Measured on Leaves of *Nerium oleander* Collected in 20 Stations in Palermo Area. (Relative Standard Deviations Range from 5 to 15%)

Compounds	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
	Alpi	Lazio	Basile	Department	Indipen	Indipen 2	Court	Industrial	Alcide	Harbour	Leoni	A. Corsari	Agip	Botanic	Aspra	Porticello	Cefalu	SS 113	Mille	Tukory
Acenaphthylene	3,55	0,74	0,6	1,7	1,5	3,9	4,8	2,4	4,6	2,56	4,33	0,00	0,00	0,71	0,11	0,14	0,21	0,00	1,45	5,81
Acenaphthene	0,67	0,33	5,8	1,3	0,0	0,6	0,2	0,0	0,5	0,28	0,33	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,27	0,45
Fluorene	4,80	2,68	22,3	3,1	2,8	3,6	2,0	1,2	5,2	2,97	5,86	1,05	1,35	1,00	1,58	1,14	0,61	1,02	2,70	5,46
Phenanthrene	6,37	10,02	4,0	11,6	10,5	12,4	10,8	4,7	9,1	12,36	28,11	5,49	8,72	6,72	6,21	4,39	2,62	4,25	11,58	17,24
Anthracene	0,55	0,79	1,4	0,8	0,8	1,0	0,9	0,3	0,6	1,12	1,72	0,48	0,54	0,26	0,43	0,35	0,21	0,36	0,69	2,40
2 methyl	0,14	0,15	0,0	0,1	0,1	0,1	0,3	1,4	0,2	0,64	0,85	0,00	0,00	0,00	0,77	0,82	0,07	0,65	0,00	0,00
anthracene																				
9 methyl	0,00	0,00	22,7	0,1	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
anthracene																				
Fluoranthene	4,37	4,53	34,9	21,0	4,9	5,1	5,5	2,4	3,8	11,24	7,76	2,34	4,04	18,95	3,43	1,99	1,03	2,31	4,57	11,55
Pyrene	5,64	4,93	3,4	28,2	5,8	5,2	6,1	1,8	3,8	13,72	8,63	2,66	3,19	14,43	3,01	1,70	1,14	2,47	5,19	15,10
1 methyl	0,69	0,55	8,2	0,1	0,7	0,8	0,6	4,2	0,3	0,95	0,98	0,28	0,34	0,44	0,00	0,27	0,23	0,52	0,44	1,24
pyrene																				
Benzo(a)-	1,55	0,97	35,7	0,2	1,1	0,9	0,5	1,5	0,7	17,36	1,59	0,37	0,37	0,47	0,25	0,36	0,55	0,56	1,27	2,85
anthracene																				
Chrysene	5,12	3,53	15,3	3,8	4,6	2,9	8,1	2,4	5,5	2,90	6,73	1,83	2,01	2,76	0,91	0,85	2,33	1,03	4,44	16,57
Benzo(b)-	2,71	1,18	2,5	0,0	1,4	0,7	2,2	4,2	2,5	7,03	2,21	2,15	1,07	1,88	0,50	1,25	0,83	1,90	1,52	6,80
fluoranthene																				
Benzo(k)-	0,51	0,00	1,2	0,0	0,5	0,0	0,0	3,7	0,0	0,89	0,37	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,00	0,85
fluoranthene																				
Benzo(a)-	0,31	0,00	2,7	0,0	0,0	0,0	0,0	0,0	0,0	0,46	0,53	0,00	0,00	0,00	0,00	0,60	0,00	0,00	0,13	0,00
pyrene																				
Perylene	0,86	0,58	0,0	0,0	0,8	0,0	0,0	7,5	0,0	1,39	1,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,22	15,97
Indeno(1,2,3-cd)-	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,35
pyrene																				
Dibenzo(a,h)-	0,00	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,31	6,89
anthracene																				
Benzo(g,h,i)-	0,00	0,00	0,6	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,98	2,05
perylene																				

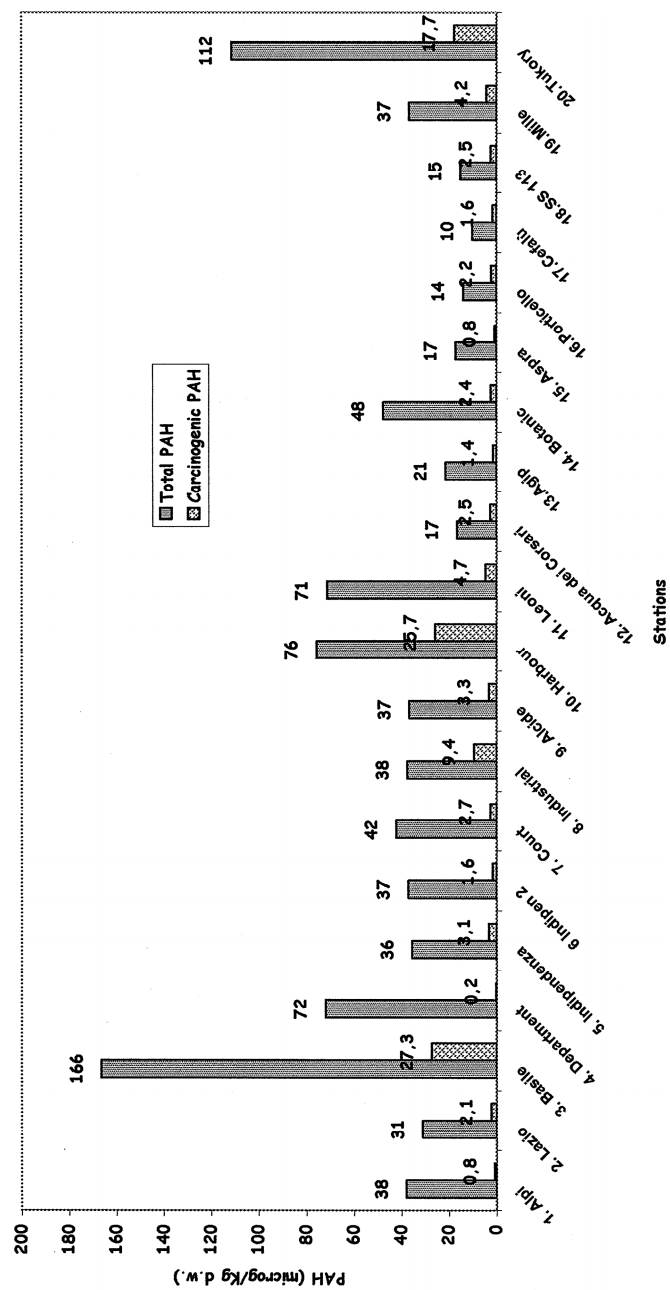


FIGURE 2. Total and carcinogenic PAHs content in the leaves of *Nerium oleander* L.

PAH [31], in this case we can suppose that the compound can be formed during the combustion of coal and used engine oil (present in old engines utilized as raw material) in the iron foundry near the station.

240 The molecular patterns generated by each source are like fingerprints and it is possible to hypothesize which processes generate PAH by studying their distribution in leaves.

245 If we group the polycyclic aromatic compounds in different classes, depending on the number of aromatic rings present in their structure, it can be observed that PAH having 3 and 4-rings, found in leaves of all sites under investigation, contribute from 82 to 97% of the total except for the station n° 8 (Industrial Area), where 5 rings PAH contribute about 40%.

250 The relative abundance of the PAH present can be used to elucidate sources and provide a source *fingerprint* (32, 33). Sources of the PAH pollution in the systems under investigation have been estimated, in a similar way to that reported for other matrices (34–37), by using distribution indexes relative to concentration ratios of some polycyclic aromatic compounds. To minimize confounding factors such as differences in volatility, adsorption, water solubility, and so on ratio calculations usually are restricted to PAH within a given molecular mass. PAH of molecular mass 178 and 202 are commonly used to distinguish between combustion and petroleum sources. Phenanthrene (Ph) and Anthracene (An) are two structural isomers. In particular, Phenanthrene is more thermodynamically stable than Anthracene; therefore, in PAH petrogenic pollution the Ph/An ratio is very high, while during the combustion processes the high temperatures favor the Anthracene formation with a lowering of the Ph/An ratio.

265 The fluoranthene:pyrene ratio can be applied to this end, generally and for different matrices a ratio of about 0.6 indicating vehicular emissions, a ratio of about 1.0 indicating that the contamination by PAH is due to combustion processes (wood smoke) as a source and about 1.4 is characteristic of emission of coal combustion. Our data indicates (Figure 3) that in the leaves collected in n° 1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 18 stations, 270 mainly affected by vehicular traffic, the mean value of Fl/Py results about 0.85. While the stations n° 8 (Industrial Area), 13 (Agip), 14 (Botanic Garden), 15 (Aspra), and 16 (Porticello) are, in part, affected by wood and coal combustion.

275 High values of phenanthrene:anthracene ratio indicate contamination from petroleum products or from coal tar. The data, shown in Figure 4, indicates that the station n° 13 (AGIP) and n° 14 (Botanic Garden) are affected, in part, from this type of emission. As seen in Figure 4, the stations are the object of the same type of emissions formed into groups.

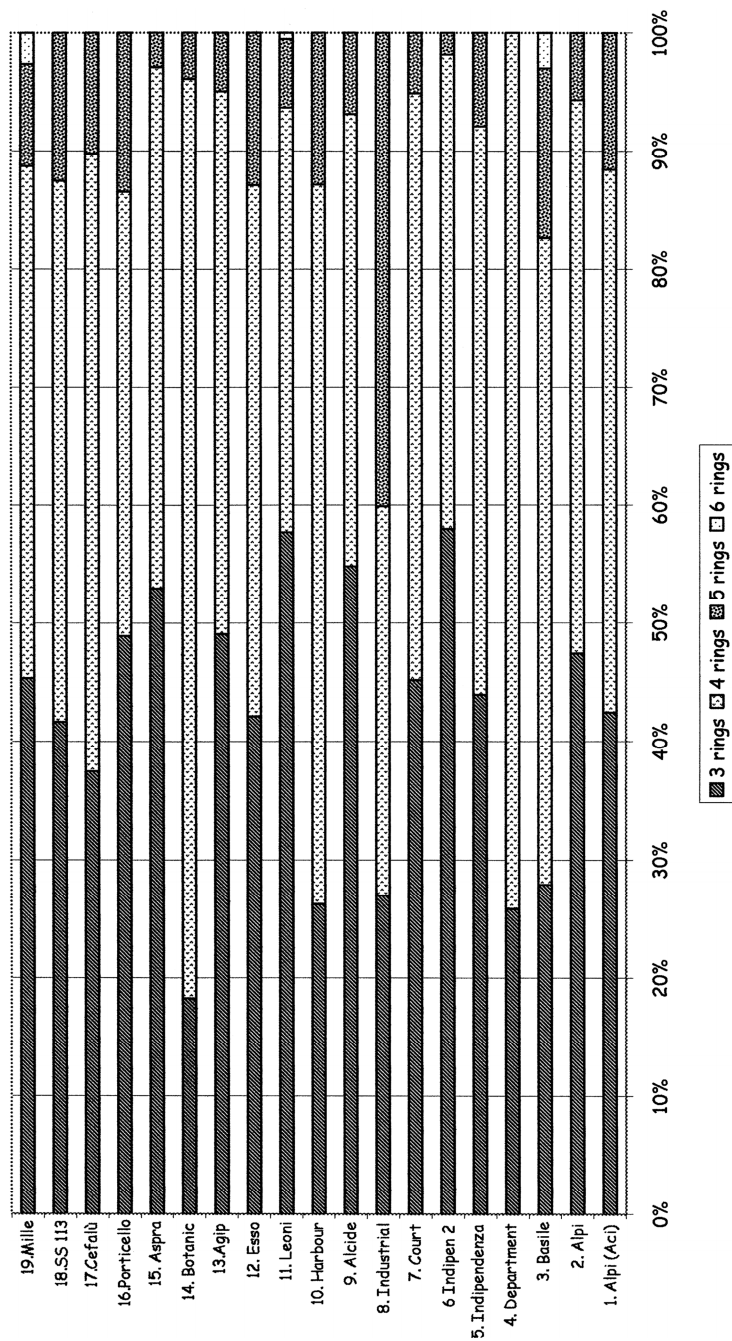


FIGURE 3. Fraction % of 3-4-5-6 rings.

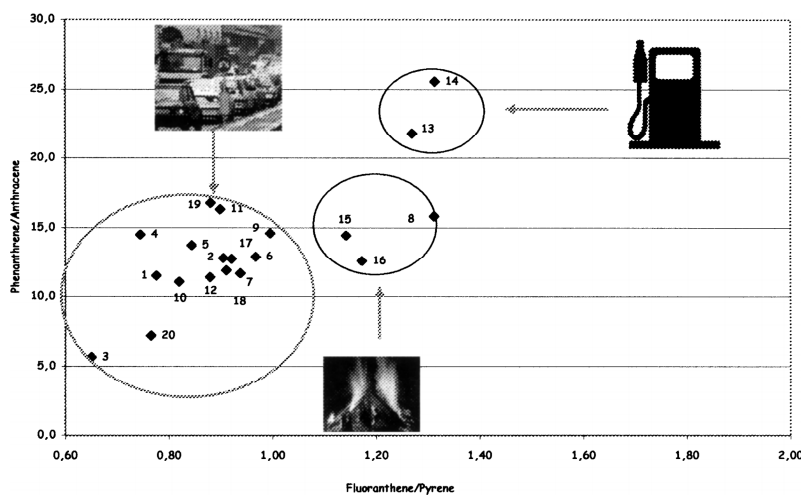


FIGURE 4. Plot of ratio Phenanthrene/Anthracene vs. ratio Fluoranthene/Pyrene.

280 The contribution of methylated PAH to the total differed with the site and with the sources. The stations (n° 3, 13, 18) not affected by urban traffic show the highest values. The reason for this is that the PAH rich diesel fuel contains a relatively high amount of alkylated PAH compared to parent. Thus at low temperature and low exhaust temperature the MePAH/PAH ratio is high, while it decreases with increases in combustion and exhaust temperature. Nevertheless, compared to other sources, for example, petrol engines, the MePAH/PAH emission ratio is higher from diesel engines (38). The contribution of carcinogenic PAH (Table 3) to the total differed with the site.

TABLE 3. Cancerogenic PAHs and Their Toxic Equivalent Factors (38)

Compounds	Toxic equivalent factors (38)
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Benzo(a)pyrene	1
Dibenzo(a,h)anthracene,	1
Indeno(1,2,3-c,d)pyrene	0.1

The burden of carcinogenic PAH (Figure 2) ranged from 0.02 $\mu\text{g}/\text{Kg}$ d.w to 8.0 $\mu\text{g}/\text{Kg}$ d.w. (expressed as benzo(a)pyrene), the lowest were found in open areas, the highest in roadsides (Figure 1). In the urban sites it was evident that the contribution of carcinogenic PAH was higher than in control sites. With the aim to find a relationship between the content of total PAH in the leaves and the concentration of particulate-benzene and CO measured in air of Palermo (39), we carried out a linear regression analysis whose results are reported in Figure 5. The concentrations of PAH are significantly correlated with the considered parameters ($r_{\text{particulate}} = 0.84$, $r_{\text{benzene}} = 0.57$, $r_{\text{CO}} = 0.83$). For comparison we used data from stations which, in geographical

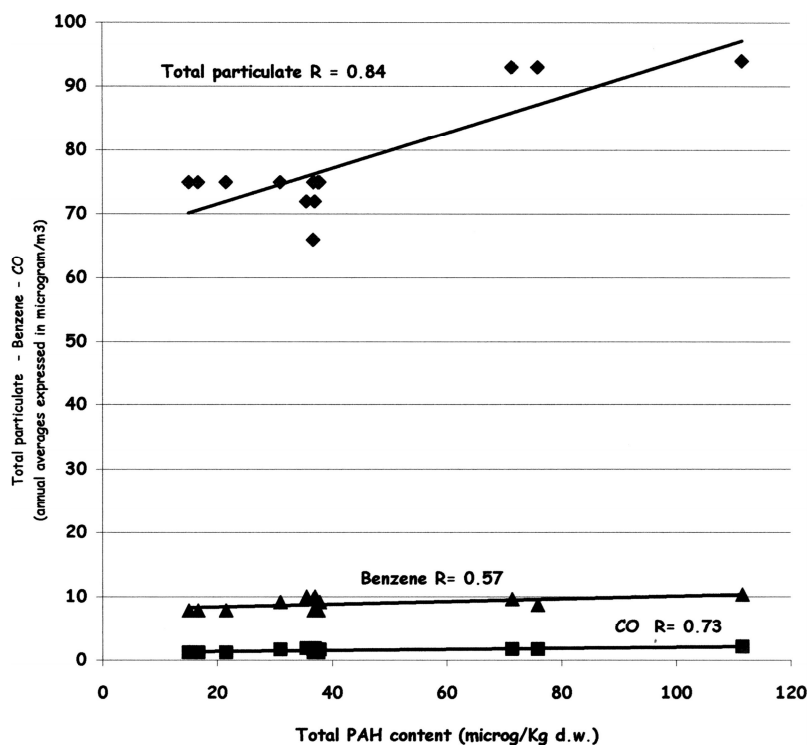


FIGURE 5. Correlation between total PAHs determined in the leaves of *Nerium oleander* and Total particulate ($\mu\text{g}/\text{m}^3$ annual average), Benzene ($\mu\text{g}/\text{m}^3$ annual average), CO ($\mu\text{g}/\text{m}^3$ annual average) measured in air of Palermo.

position, can be considered close to those in which we carried out the sampling.

CONCLUSIONS

The reported analytical method is more convenient than that utilized in previous research (27–28) because it permits the overall analysis to be completed in fewer stages. The advantages of using ultrasonic extraction over classical solvent extraction (Soxhlet extraction) and the use of the Equity-5 capillary column include less solvent consumption and shorter extraction time. Under these conditions, the reproducibility is also satisfactory, in fact, relative standard deviations ranged from 5 to 15%.

The higher amounts of PAH detected in leaves of *Nerium oleander* from the urban area of Palermo compared to the control site are diagnostic of air contamination, in particular in the zones with heavy traffic. Industrial activity is spread out in the area and is not an important source of the pollutants studied here. The wide range of leaf PAH concentrations found in the investigated area reflect strong gradients of pollution attributable to sources as well as to different degrees of air dispersion. The contribution of carcinogenic PAH to the total is higher in urban than in control and in rural and open areas.

The comparison clearly indicates that the determination of total PAH concentrations in the leaves of *Nerium oleander* offers the possibility to assess the quality of the air, in a determined geographical area related to a reference station. This method is not substitutive of classical methods but offers an additional source of information. In such a way, the need for long periods of sampling with complex, difficult to handle instruments and numerous analytical calculations is avoided. Moreover, the results obtained with the analysis carried out on a sample of leaves provides a mean information from the time of budding until final collection, uninfluenced, as occurs with traditional analysis, by meteorological conditions at the time of sampling.

Also stored samples of vegetation can be used for retrospective PAH analysis, if the set of samples extends over long periods and they have been collected and stored in the same manner over time, this approach can potentially provide a reliable date record of changes in the PAH concentration of this media.

Owing to the fact that this type of survey is more rapid and economical, it may be used for small communities and even for private citizens who wish to “get to know” the environment in which they live or in which they intend to live.

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