Population Exposure to PAH EXPAH

EXPAH ENV/IT/000082 September 2012, Issue 2

Welcome to 2nd issue of the Newsletter

Editorial

The EXPAH partners are pleased to present the second issue of the EXPAH project Newsletter.
The purposes of the newsletters are to inform about activities, progress, and achievements of the EXPAH project, to establish a communication link between end-user and partners, as well as with the Collaborators, and Stakeholders Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters as well as comments are always welcome (send to **expah@asplazio.it**).

In this number a brief introduction to the latest results delivered by the EXPAH project is given. The winter indoor/outdoor monitoring results of both Polycyclic Aromatic Hydrocarbon (PAH) and VOCs compounds in schools, homes and offices with PAHs personal exposure are available and briefly presented. A statistical analysis of meteorological data collected in the city of Rome is also shown. The latest results of modeling activities are also presented. In this Newsletter descriptions and progress in these fields are briefly presented.

The LIFE+ EXPAH Project

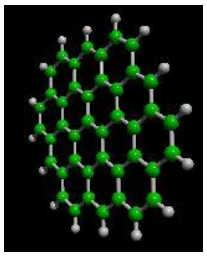
The European Community funded a project (EXPAH) by means of LIFE financial instrument, with the aim to identify and to quantify population exposure among children and elderly people to Polycyclic Aromatic Hydrocarbons (PAHs) content in particulate matter in highly urbanized areas and to assess the impact on human health, in order to support environmental policy and regulation in this field. The city of Rome has been chosen as study area.

An integrated project: The project is based on an integrated approach where measurements, modeling techniques and epidemiologic investigations will be used to obtain estimation maps of population exposure to PAHs, to identify key determinants of high exposures including time-activity and locations in relation to the sources and to estimate potential health effects on the target population.

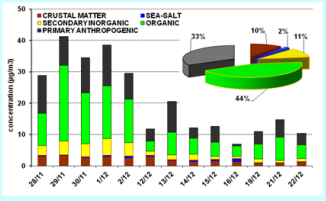
"What if": Analysis will be conducted to evaluate the effectiveness of possible reduction measures of exposure.

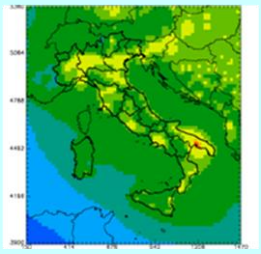
Expected results:

- A full emission inventory for air pollutants with PAHs for Rome;
- A dataset of indoor-outdoor $PM_{2.5}$ and speciated PAHs with personal exposure;
- Exposure maps of $PM_{2.5}$ and PAHs for Rome;
- A database for health assessment of $PM_{2.5}$ and PAHs.



Content





EXPAH Progress Status

The LIFE+ EXPAH project has reached the first 21 months of lifetime. Last June 2012 it finalized the Mid Term Report which presents the results of the first part of the project and evaluates the project progress against the objectives and work plan.

During the latest period the activities have been focused on the following:

- Continuous seasonal survey of time-activities of children and elderly people living in the city of Rome;
- Finalization of the preliminary field campaign in two schools and one office to assess PAHs, EC/OC, metals and VOCs concentrations in indoor and outdoor environments as well as to compare the intra/inter-laboratory measurements end performances of different PM samplers.
- Winter and summer field campaigns of indoor/outdoor PAHs, PM2.5 and its components, VOC in 20 living places among schools, homes, offices, cars and buses.
- Winter PAHs personal exposure measurements of children and elderly people living in the city of Rome.
- Finalization of the meteorological field campaign in 4 stations to collect upper air and surface data with turbulence and statistical analysis of the provided data.
- Finalization of the model ready PAH emission inventory for the studied area.
- Upgrade of the Chemical Transport Model FARM to deal with PAHs compounds.
- Starts of meteorological model simulations for the reference year (summer 2011-summer 2012).
- Starts of simulations of PAHs, PM2.5 and gaseous pollutants in the national domain for providing boundary conditions in the target domain.

Recent Reports

- Comparison study of PM2,5 chemical composition by using MV and LV samplers. Techical Report - action 3.2.2. http://www.ispesl.it/expah/documenti/TechicalReport-ComparisonstudyofPM2,5chemicalcomposition
- Long range transport of PAHs and definition of computational domains for Rome city simulations. Action 4.2. http://www.ispesl.it/expah/documenti/Expah_4.2_computational_domain_&_minni2005.pdf
- Ancillary Measurements and the Intercomparison Study – Action 3.2.3 Inter-comparison. http://www.ispesl.it/expah/documenti/TechnicalReport_CNR_01%20action%203.2.3.pdf
- Collection of raw emission inventories and their upgrading. ACTION 4.1. http://www.ispesl.it/expah/documenti/R2011-13_ARIANET_EXPAH_A4.1.pdf
- Technical Report on activities carried out by CNR-IIA and INAIL - ex ISPESL in the frame of the EXPAH Project (Actions 3.2). http://www.ispesl.it/expah/documenti/TR_2011_CNR-INAIL.pdf
- Instructions, information and remarks for the regular in-field campaigns of the EXPAH Project (Laboratory and in-field activities), Action 3.2. http://www.ispesl.it/expah/documenti/TR_2011_CNR-INAIL-recommandations%20action%203.2.pdf
- Integration of PAHs atmospheric processes within FARM model. http://www.ispesl.it/expah/documenti/R2012-01_ARIANET_EXPAH_A4.5.pdf
- Calculation and integration of traffic emissions with the updated Lazio Region inventory. http://www.ispesl.it/expah/documenti/R2012-05_ARIANET_EXPAH_A4.3-4_final.pdf
- Preliminary report on time-activity data of population groups of Rome. http://www.ispesl.it/expah/documenti/preliminary%20technical%20report%20action%203.1.pdf
- Technical report on meteorological measurements (action 3.4). http://www.ispesl.it/expah/documenti/Technical%20report%20on%20meteorological%20measurementsrev1.pdf

Recent presentations and publications

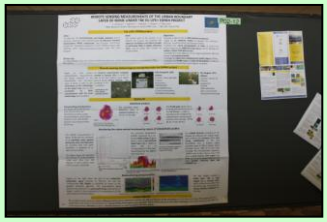
- 8th International Conference Air Quality - Science and Application, Athens 2012. The LIFE+ Population Exposure to PAH (EXPAH) Project: indoor/outdoor monitoring and emissions estimation in Rome. http://www.ispesl.it/expah/documenti/AQC2012-garic00536.pdf
- Eurotox Conference - 47th Congress of the European Societies of Toxicology, (Porte Maillot, Paris, France). http://www.ispesl.it/expah/documenti/Poster_Expah%20Eurotox.pdf
- V convegno nazionale Il Controllo degli Agenti Fisici: Ambiente, Salute e Qualità della Vita. Novara giugno 2012. Il Progetto LIFE+ Population Exposure to PAH (EXPAH): esposizione Indoor/outdoor in ambienti di vita e stima delle emissioni nella città di Roma. http://www.ispesl.it/expah/documenti/A12%20-%20GARIAZZO_ET%20_ALL.pdf
- Convegno Nazionale AMBIENTE, ENERGIA, SOSTENIBILITA' NEI PROGETTI LIFE ITALIANI. Brescia – Italy May 2012. Progetto EXPAH (population EXposure to PAH): risultati del monitoraggio indoor/outdoor e stima delle emissioni di IPA a Roma. http://www.ispesl.it/expah/documenti/expah_brescia_8min.pdf
- 16th International Symposium for the Advancement of Boundary-Layer Remote Sensing. Boulder – Colorado USA June 2012. http://www.ispesl.it/expah/documenti/ISARS%202012%20Extended%20Abstract%20gariazzo%20et%20al_rel3.pdf
- 5th National Symposium on Atmospheric Particulate (PM2012). Perugia -Italy June 16th-18th, 2012. Progetto EXPAH: IPA cancerogeni in ambienti indoor (scuole, case, uffici, veicoli)
- Seminar at CNR-ISAC National Research Institute. http://www.isac.cnr.it/documenti/seminari/Gariazzo_Claudio_pre_20120502.pdf

Achieved milestones and deliverables

- Kick-off EXPAH meeting
- Website finalisation
- Finalisation of a model ready PAHs emission inventory
- End of collection and analysis of meteorological data

Dissemination activities

To the scientific community



Poster at ISARS 2012 conference

As for the dissemination to the scientific community both poster and oral presentations have been done at National and international scientific conferences. The list of conferences is below:

- 47th EUrotox Paris – France 28-31 august 2011
- 8th Air Quality Athens – Greece 19-23 March 2012
- AMBIENTE, ENERGIA, SOSTENIBILITA' NEI PROGETTI LIFE ITALIANI Brescia – Italy May 2012
- 5th Il controllo degli agenti fisici: ambiente, salute e qualità della vita Novara – Italy June 2012
- 16th ISARS 2012 Boulder – Colorado USA June 2012
- 5th PM2012 Perugia -Italy June 2012
- Seminar at ISAC-CNR Institute

To the Pubblic

Indoor monitoring at

Outdoor monitoring in car

Lesson at primary

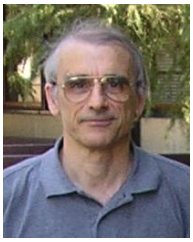
Monitoring at school

Monitoring at a urban park

Monitoring at gym

As for the dissemination to the public a lesson to a primary school was given. A picture of it is shows beside. In addition, information panels were installed at the EXPAH meteorological stations as well as in the locations of project implementation (schools, cars, buses, offices) to disseminate project's aims and objectives. Examples are shown beside.

Indoor and outdoor PAHs in the schools and dwellings of Rome in winter time



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In the frame of the Life+ EXPAH project, particulate PAHs were measured during winter 2011-21 in schools, homes and an office in Rome, Italy. Indoor concentrations were compared with the corresponding outdoor values and with data recorded at three ARPA Lazio Network stations. Our study was focused on seven "carcinogenic" PAHs (benz[a]anthracene, benzo[b]fluoranthene, benzo[j]-fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene and dibenz-[a,h]anthracene) and two mutagenic congeners (chysene and benzo[ghi]perylene). The times and locations of study (Fig. 1) were: *i)* Nov. ÷ Dec. 2011, three schools; *ii)* Jan. ÷ Feb. 2012, four private houses and anoffice; and *iii)* both periods, ARPA Lazio stations

Fig. 1 – *Monitoring sites. Symbols: ho: houses; sc: schools; of: office.*

Particulates (PM2.5) were collected daily, weighted, pooled weekly and characterized for PAHs. Three sets of samplings were performed at each site.

Results

The results of the two in-field experiments are summarized by Figs. 2-3 and 4-5.

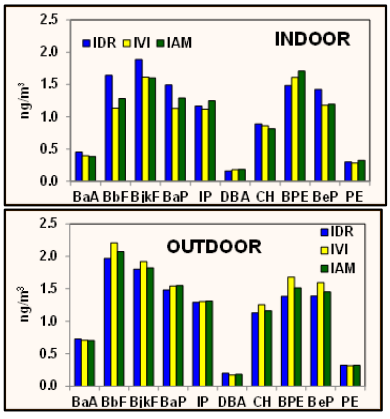


Fig. 2 *– Average PAH concentrations in three schools. Rome, Italy, Nov. 28 – Dec. 22, 2011. IDR: Istituto Don Rua; IVI: Istituto G.B. Vico; IAM: Istituto Alberto Manzi; a) indoor; b) outdoor.*

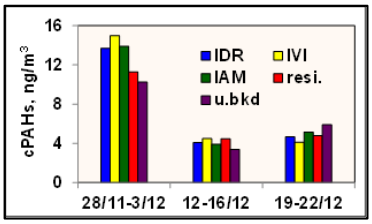


Fig. 3 *– Weekly trend of carcinogenic PAHs in schools and ARPA stations. Rome, winter 2011-12. Resi.: ARPA stations, residential sites; u.bkd: urban background; cPAHs = sum of carcinogenic PAHs.*

PAH burdens in the schools were similar (Fig. 2) and indoor values were comparable to the outdoor ones. The weekly trend was similar to that of ARPA Lazio stations (Fig. 3).

Fig. 4 reports the average PAH concentrations recorded in four private houses (HAC, HCB, HPE, HTR) and in the office (ARP), Jan. ÷ Feb. 2012.
The PAH burdens were more variable compared to schools, and indoor values were lower than outdoor (in/out ratios ranging 0.3÷0.8). Nonetheless, the weekly trend was similar indoors and outdoors at all sites comprising the ARPA stations (Fig. 5).

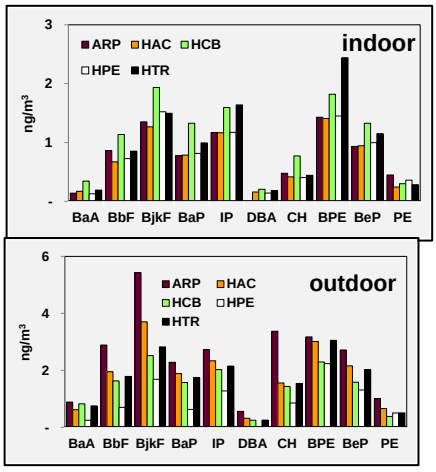


Fig. 4 – *Average PAH concentrations in houses and an office (ARP). Rome, Italy, Jan. 16 – Feb. 03, 2012; a) indoor; b) outdoor.*

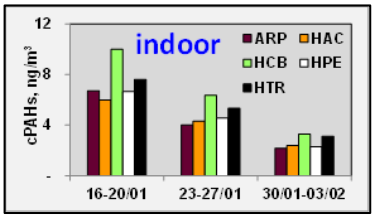
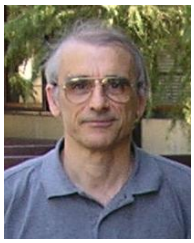


Fig. 5 – *Trends of carcinogenic PAHs in four houses and an office of Rome in winter 2012. cPAHs = sum of the seven carcinogenic PAHs.*

Conclusions

The in-field experiments of winter 2011-12 confirm that indoor environments are exposed to important concentrations of PAHs, comparable to outdoor air.

Indoor and outdoor VOCs in the schools and dwellings of Rome in winter time



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VOCs (volatile hydrocarbons) were monitored during winter 2011-21 in schools, homes and an office in Rome, Italy, by means of diffusive sampling. Indoor concentrations were comp-ared to the corresponding outdoor values and, only for benzene, to data recorded at stations belonging to the ARPA Lazio Network for atmospheric pollution control. Our study was focused on BTEX, namely on benzene and its C_1-C_2 derivatives. In addition nitrogen dioxide, ozone and the fine fraction of aerosols ($PM_{2.5}$) were measured. Three schools were studied in Nov. ÷ Dec. 2011, and four private houses and an office in Jan. ÷ Feb. 2012. Data from ARPA Lazio stations were collect-ed in both periods.

Fig. 1 – *Monitoring sites. Symbols: ho: houses; sc: schools; of: office.*

The "ancillary" measurement of regulated toxicants (i.e. VOCs as well as NO_2, O_3 and $PM_{2.5}$) was important to discriminate the specific impact of PAHs and draw information about sources of indoor pollution.
VOCs were captured with diffusive samplers, solvent extracted and analysed through GC-FID. Chlorobenzene was adopted as internal reference compound. One average value over the campaign period (three weeks) was obtained for each target compound and two diffusive samplers were co-located in each site, in parallel to a pair of blanks. Ozone and nitrogen dioxide were determined similarly by analysing aqueous extracts through IC. $PM_{2.5}$ was collected at low-volume conditions and determined daily by weighting on micro-balance.

Results

Fig. 2 shows the BTEX concentrations recorded indoors and outdoors in three schools of Rome, i.e. Istituto Alberto Manzi (IAM), Istituto Don Rua (IDR) and Istituto G.B. Vico (IVI), from Nov. 28 to Dec. 22, 2011. Total burdens and percent distributions changed with site. In particular, peculiar behaviours were presented indoors at IDR, while the other sites and compounds modulated in parallel.

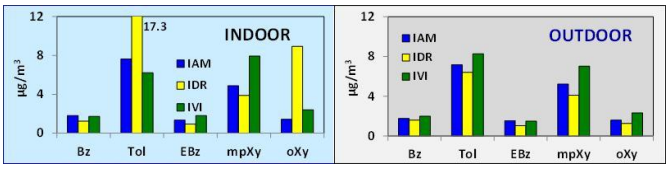

Fig. 2 – *VOCs in schools. Nov. 28 – Dec. 22, 2011: Bz: benzene; Tol: toluene; EBz: ethylbenzene; mpXy: m/p-xylene; oXy: o-xylene.*

The indoor/outdoor concentration ratio was ≈1 (0.8 ÷1.2) for all schools and compounds, except toluene (~2.7) and o-xylene (~7) at IDR, suggesting that solvent-containing products were used there.

Fig. 3 shows VOCs recorded in the private houses (HAC, HCB, HPE, HTR) and in the office (ARP). Indoors, total VOCs and percent profiles were similar at all sites except for HPE. There, C_2-benzenes were more important than benzene and toluene. By contrast, outdoors the concentrations were higher at HAC, whose balcony faced a duty traffic road hosting two petrol stations. The in/out ratios ranged 0.8÷1.2, except for toluene (2.0) and m/p-xylene (3.7) at HPE.

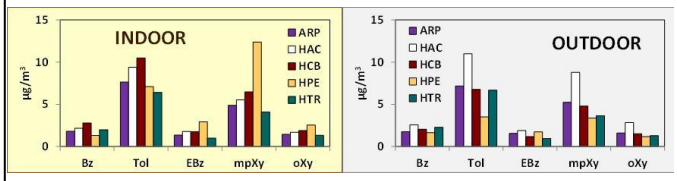

Fig. 3 *– BTEX concentrations in four houses (HAC, HCB, HPE, HTR) and an office (ARP) of Rome, Italy. Jan. 16 – Feb. 03, 2012.*

Indoor $PM_{2.5}$ at the three schools (Nov. ÷ Dec. 2011) is shown in Fig. 4. $PM_{2.5}$ was similar at the three sites and comparable to that of ARPA stations (Fig. 5). The in/out ratios were broadly constant (≈0.9).

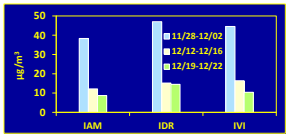

Fig. 4 – *$PM_{2.5}$ in three schools of Rome. Nov. 28 – Dec. 22, 2011.*

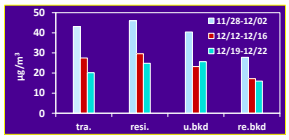

Fig. 5 – *$PM_{2.5}$ at ARPA Lazio stations. Rome, Nov. 28 – Dec. 22, 2011.*

At schools and the office the variability was large with both site and time (Fig. 6). The highest values were measured in HCB concurrently to the maximum mean in/out ratio (≈1.8) (Spotty contamination by smokers occurred). The minimum indoor concentrations and in/out ratios (~0.4) were found in the office. Indoor data were often higher than those detected by ARPA.

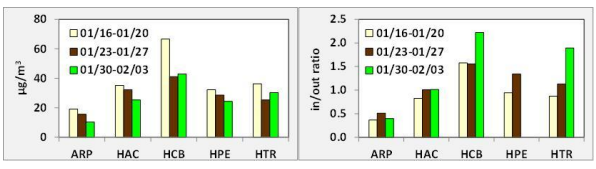

Fig. 6 *– $PM_{2.5}$ in four houses and an office of Rome. Jan. 16 – Feb. 03, 2012; a) indoor concentrations; b) in/out penetration ratios.*

Indoor/Outdoor $PM_{2,5}$ chemical composition in schools

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The measurements concerning $PM_{2.5}$ mass concentration and chemical analysis were designed in order to obtain a data set of the PM composition in the urban area of Rome and to evaluate the effect of outside pollution on the air quality of different indoor environments, such as schools, houses, offices, buses and cars.
The main results of a field campaign carried out in one of the selected school are presented in this page. Samplings took place indoor and outdoor the school, located in Rome downtown; they were scheduled over three weeks during the wintertime (November 28th - December 23rd). The analysis of the water-soluble inorganic fraction, elements, organic carbon and elemental carbon was carried out on each sample.

Mass concentration, daily and average composition

The comparison between indoor and outdoor mass concentration shows that indoor values are lower during the entire sampling period (Fig. 1). In particular, the difference is pronounced during the first week, when a strong atmospheric stability occurred and the measured concentration were much higher than the target value of 25 μg/m^3 recommended in the EC Directive 50/2008.
For a better evaluation of the day-to-day PM variations, we considered the PM mass calculated as the sum of the following macro-sources[1]: soil, sea-spray, combustion, inorganic secondary species and organic matter. The daily concentration of indoor and outdoor $PM_{2.5}$, determined according to this classification, are shown in Figs. 2 and 3, respectively; the average composition of the whole period is reported in the pie graph. In Table 1 we report the day-by-day concentration values of each macro-source considered in the model.
The istograms show that $PM_{2.5}$ is mainly composed of organic and primary anthropogenic species while natural sources (soil and sea), as expected, show a lower contribution. In details, as shown in Table 1, small differences between indoor and outdoor values are observed for combustion sources during the entire period of sampling. Outdoor organics are higher during the first week (I/O ratio 0,57) while variable small difference are detected during the second and third week (I/O ratio 1,05). Secondary inorganic contribution, that originates from secondary reactions in atmosphere, shows higher values outdoor with a minimum on the 12th and 16th December probably due to advection episodes. Sea-salt contribution is higher outdoor with a maximum on 16th December due to a sea-spray event. Finally, it is worth noting that the indoor/outdoor ratio of the crustal matter fraction show a high day-by-day variability; the use of chalk and the re-suspension during other indoor activities may explain the observed variability.

References

*Perrino C., Canepari S., Pappalardo S., Marconi E., **2010**. Chemosphere 80, 1291-1300.*

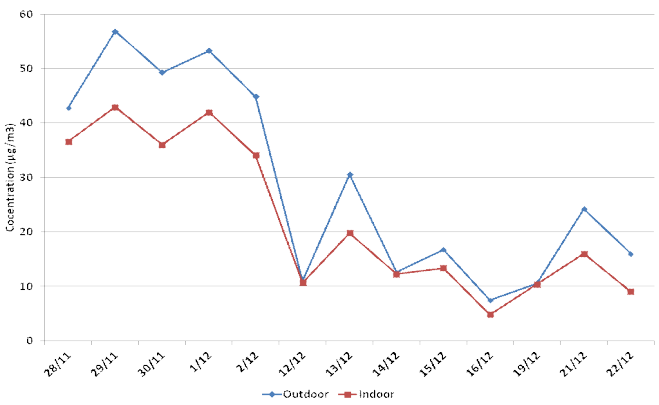

Figure 1: *Indoor and outdoor $PM_{2.5}$ mass concentration at a school site*

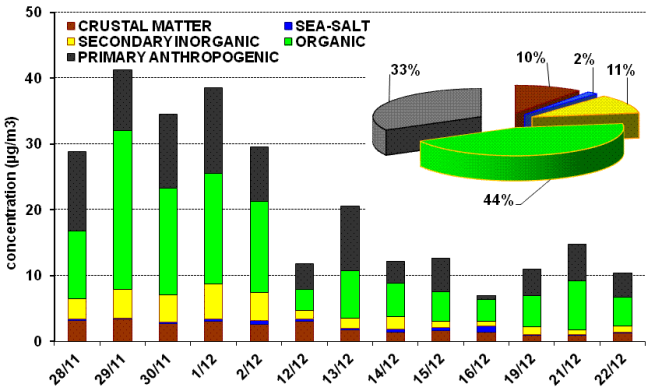

Figure 2: *Indoor daily concentration (columns) and average composition (pie) of the five macro-sources*

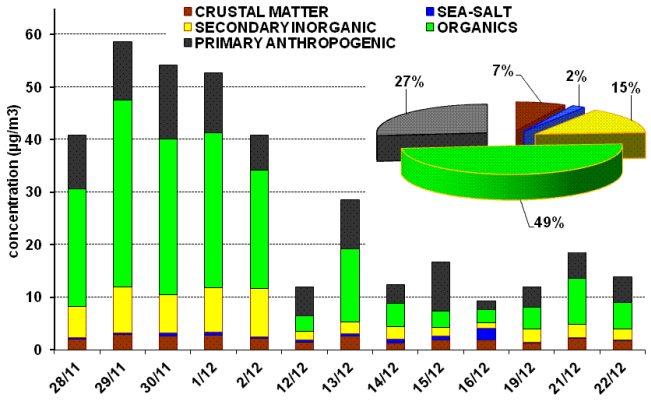

Figure 3: *Outdoor daily concentration (columns) and average composition (pie) of the five macro-sources*

	CRUSTAL MATTER		SEA-SALT		SECONDARY INORGANIC		ORGANICS		PRIMARY ANTHROP.	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
28/11/2011	3,2	2	0,16	0,33	3,1	5,9	10,3	22,4	12	10,3
29/11/2011	3,4	2,9	0,18	0,42	4,4	8,7	24,2	35,6	9,2	11,1
30/11/2011	2,7	2,6	0,26	0,56	4,1	7,3	16,3	29,7	11,3	14,1
01/12/2011	3,1	2,8	0,33	0,54	5,4	8,4	16,8	29,5	13	11,5
02/12/2011	2,6	2,2	0,52	0,25	4,3	9,2	13,9	22,6	8,3	6,7
12/12/2011	3,1	1,5	0,29	0,38	1,3	1,7	3,2	2,9	4	5,5
13/12/2011	1,7	2,7	0,30	0,45	1,5	2,2	7,3	13,9	9,8	9,4
14/12/2011	1,4	1,4	0,45	0,63	1,8	2,4	5,1	4,5	3,4	3,6
15/12/2011	1,6	1,9	0,45	0,77	0,9	1,5	4,5	3,2	5,2	9,2
16/12/2011	1,4	1,9	0,96	2,23	0,7	1,1	3,3	2,4	0,6	1,6
19/12/2011	0,9	1,4	0,12	0,16	1,2	2,5	4,8	4,1	4,1	3,9
21/12/2011	0,9	2,2	0,11	0,22	0,7	2,5	7,4	8,8	5,6	7,3
22/12/2011	1,3	1,7	0,14	0,12	0,9	2,1	4,3	5,1	3,6	4,8

Table 1: *Daily indoor and outdoor concentration(in μg/m^3) calculated*

PAH personal exposure measurements of children and elderly people

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Personal exposure measurement aimed at evaluating the actual individual exposure to fine particulate matter (PM2.5) and particle-bound polycyclic aromatic hydrocarbons (PAHs) is the main task of the action 3.3.5. For this purpose, six volunteers living in different areas of Rome, including 4 children and two elderly, are monitored during their moving through different microenvironments, especially home and school, for two fifteen days seasonal campaigns (winter and summer), on a daily based sampling. The personal exposure measurements are performed by collecting PM 2.5 at 10 L/min, reproducing the human breathing performance.
On the PM 2.5, seven "carcinogenic" PAHs, are determined, benzo(a)anthracene (BaA), benzo(b+j+k)fluoranthene (BbjkF), benzo(a)pyrene (BaP), indeno(1,2,3- cd)pyrene (IP), dibenz(a,h)anthracene (DBahA), plus the mutagenic benzoperylene (BPE). The exposure monitoring activity also consists of collection of personal time activity schedules (daily diaries) designed to record information about volunteers data and habits useful in assessing the extent of the potential absorption of PAH by different routes of exposure.

PM 2.5 and PAHs personal exposure

In this newsletter some preliminary results on personal exposure measurements carried out in April 2012 are reported. The PM 2.5 potential exposure of an elderly volunteer, for both the day and night profile, is reported in Figure 1; personal measurements show a greater potential exposure during day hours, compared to those at night; the exposure during the night time is in agreement with the average indoor contamination measured inside 5 houses in Rome, on a 24 hours sampling period (green line).

	V1	V2	V3	V4	V5	V6
% INDOOR	94%	87%	92%	87%	91%	64%
% OUTDOOR	6%	13%	8%	13%	9%	36%

Table 1: *indoor and outdoor volunteer's time as 24 hours percentage*

Although the indoor home sampling time (24 hours, 100% indoor time) is similar to the time spent from the volunteer 1 (elderly) within a confined environment (94 %, Table 1) her exposure during the day time seems to be affected by an increased indoor-generated PM 2.5 with respect to the night.

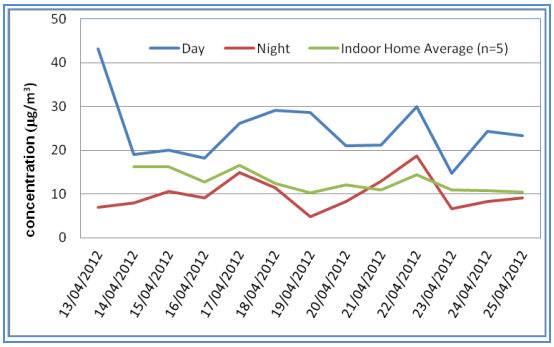

Figure 1: *Volunteer 1, $PM_{2.5}$ Day-Night exposure; Indoor h24-PM 2.5 (average values on 5 houses)*

This difference is less evident as far as PAH's concentration is concerned (see figure 2).

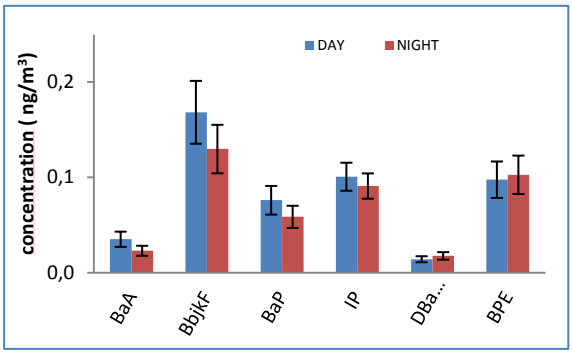

Figure 2: *Volunteer 1, PAHs day-night exposure (1st week average)*

Moreover, the percentage composition of PAHs appears very consistent in all cases of exposure experienced, also including the day-night discrimination (figure 3).

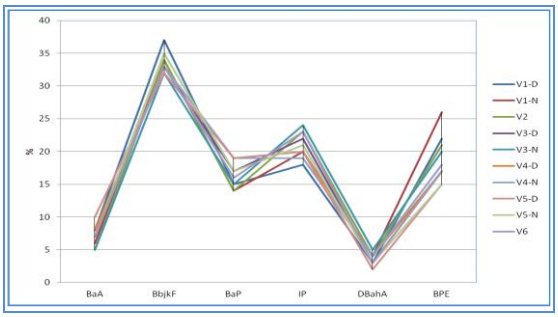

Figure 3: *Personal exposure PAH's relative composition*

These preliminary results, showing a PM 2.5 day/night concentration ratio higher than 1 for all volunteers, allow us to hypothesize an exposure to dust re-suspended by indoor anthropogenic activity during the daytime, whilst the sources of PAHs remain homogeneous both from the point of view of spatial and temporal distribution.
So far, the importance of evaluating the exposure by discriminating the daily performances from the night ones, even if no "physical activities" are measured, appears central in formulating any theory on source apportionment: further analysis of the daily diaries aimed at discriminating the routes of exposure are still in progress.

Yearly meteorological measurements in the city of Rome and statistical analysis.

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In the frame of the action 3.4 of EXPAH project was carried out a field campaign to collect meteorological measurements in the urban area of Rome and its surroundings. The aims is to detect the main local circulation patterns and provide data to action 4.5 for the reconstruction of meteorological fields by means of a modelling system. In addition to the existing monitoring network, four stations have been located in the city of Rome and its surroundings. The meteorological stations are the following:

- Villa Pamphili urban park
- Tor- Vergata science park-suburban area
- Montelibretti CNR-science park – rural area
- Monteporzio Catone INAIL Institute – rural area

In the first two stations ground-based remote sensing systems, and surface measurements which include also turbulence are carried out. The last two stations provide conventional meteorological measurements. The field campaign, started on December 2010 ended on June 2012. To obtain information on the typical behaviour of these parameters, a statistical analysis was conducted on 2011 year data set.

The wind roses at each station for the whole year and on seasonal bases using both surface and upper air data (100 and 180m agl) was done. Prevalent winds were identified at each station. Figure 1 shows the results.

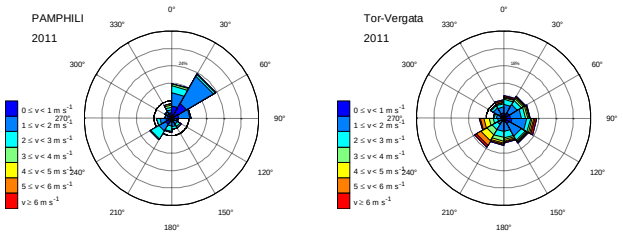

Figure 1 *Wind roses at Pamphili and Tor Vergata stations for year 2011.*

The urban station of Pamphili exhibits a strong wind polarization with a well-defined prevalent wind from the north, north-east and south west sectors. Strong wind speed (>6 m/s) are rarely detected here, being more frequent light winds (< 3 m/s). As for the Tor-vergata station, with the exception of the west-south sector, all other wind sectors seem to have roughly the same probability. The west winds are associated to high wind speeds (> 4 m/s) respect to those observed in the other sectors (< 2 m/s). It is important to investigate the mean daily variation of the meteorological parameters as it provides important information of the starting and ending time of certain phenomena, its average value and dispersion around it. For these reasons the hourly PDF functions were calculated both for wind speed and direction. Figure 2 shows some results of this analysis.

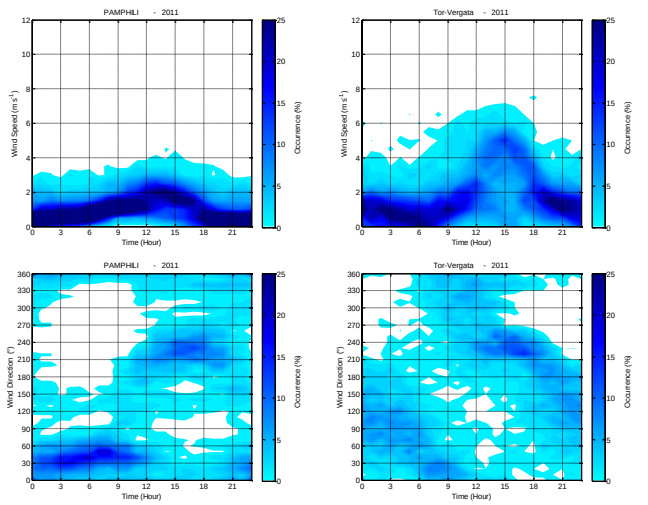

Figure 2 *Hourly PDF functions of surface wind speed and direction at PAMPHILI and Tor Vergata stations during year 2011.*

All the stations exhibit lower values of the wind speed during night. A maximum was instead observed during the day. Peak values are reached in the late afternoon (1500 ST) with intensity that depends on the station. As for occurrences of wind direction, all stations have a peak between 210° and 240° around 1200-1800 ST, which can be ascribed to sea breeze circulation. The occurrence has intensity and duration which depend on the station.

The study of the characteristics of the atmospheric turbulence contributes to understand its ability to disperse or accumulate pollutants dependending on the thermal stability. Four turbulence parameters were statistically analyzed: friction velocity (u_*), turbulent kinetic energy (TKE), standard deviation of vertical wind speed (σ_w) and the inverse of Monin-Obukhov length ($\xi = z/L$) also called stability parameter. The figure 3 shows the PDF functions for the urban station of Pamphili.

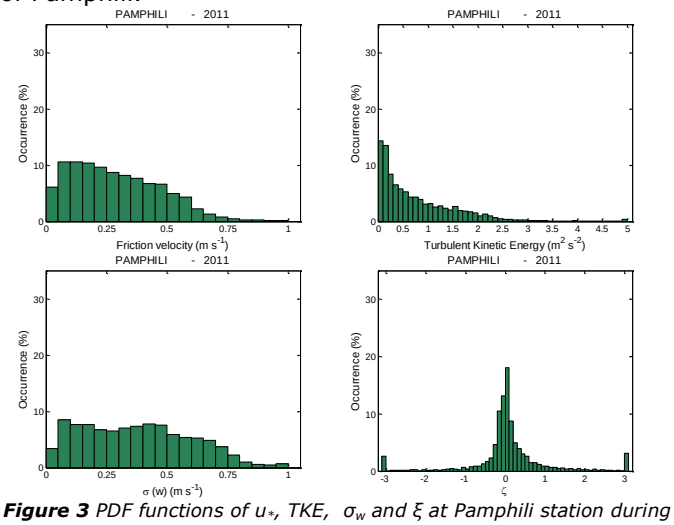

Figure 3 *PDF functions of u_*, TKE, σ_w and ξ at Pamphili station during year 2011.*

u_* presents a rather flat and broad distribution. The PDF function of TKE shows that the most likely values are those at lower range (0.25 m^2/s^2) which are normally related with thermals, while highest values, linked with the wind shear, are less frequent. The stability parameter ξ exhibits a peak at values close to zero, typical of a neutral atmosphere. Details can be found in the technical report of action 3.4.

References

C. Gariazzo, S. Argentini, I. Pietroni, A. Pelliccioni, I. Petenko ***2012****: Technical report on meteorological measurements carried out in urban and sub-urban areas of Rome in the frame of EXPAH project. Action 3.4.*

The PAH emission inventory

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In order to develop a complete emission inventory for the city of Rome and its surrounding area, it has been necessary to integrate different sources of information, in particular INCOM05 (Municipal level inventory downscaled from ISPRA2005), ISPRA historical series, point sources from ARPA Lazio inventory, ARPA Lombardia wood burning study, passengers and goods movement to/from Ciampino and Fiumicino airports, ships movement to/from Civitavecchia port, traffic flows for Lazio Region and Rome road network.

ISPRA inventory, originally referred to year 2005, has been updated to year 2009 using historical series of total national emissions published by ISPRA. Industrial emissions Region have been reviewed implementing the inventory performed by ARPA Lazio for the reference year 2009 and including 120 point sources (Figure 1). Information coming from different studies and datasets have been used to assign space distribution to different fuels burnt for residential heating, with relevant impact on wood burning emissions, first of all for PM10, NMVOC and PAHs.

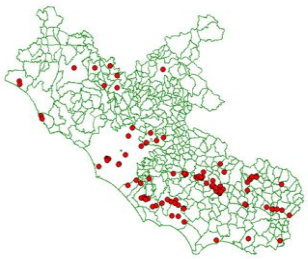

Figure 1. *Point sources in Lazio Region.*

The most significant improvement in the emission inventory has been the detailed estimation of road traffic emissions: vehicles flow for each link of Rome Province road network has have been estimated by Rome city authority for mobility and public transport, by means of a traffic assignment model, on the basis of origin–destination (OD) matrices and observed traffic data. For the remaining Lazio Provinces, traffic flow has been estimated from vehicles passages over the regional road network (AISCAT, ASTRAL and ATAC data for year 2009) through the application of the traffic assignment model CARUSO.

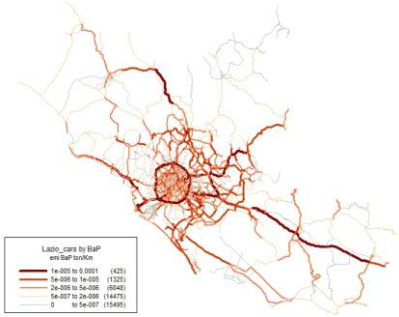

Figure 2. *B[a]P emissions (ton/Km) associated to cars over Lazio Region road network.*

Hourly emissions of all the pollutants, including PAHs congeners, have been calculated for each road link by means of TREFIC model, implementing the COPERT IV methodology. (Figure 2)

For all macrosectors but traffic, PAHs congeners emission were speciated using EMEP/CORINAIR Emission Inventory Guidebook 2009 because the national inventory only included total PAHs.

The emission input for air quality modelling has been finally obtained integrating the bottom-up evaluation of traffic emission, the new estimation of residential combustion and ports emission with the updated version of INCOM 2005 inventory.

Observing results for Lazio Region, summarized in Figure 3, it can be noticed that for all PAHs species the most important source is residential heating; looking at the different congeners, the contribution of residential combustion to Benzo[a]pyrene emission is 69% while it reaches the 78% for Benzo[b]fluoranthene and Benzo[k]fluoranthene. Waste treatment represents the 21% of total PAHs emissions but its contribution varies very much with the different species: it produces the 29% of B[a]p and the 18% of B[b]f.

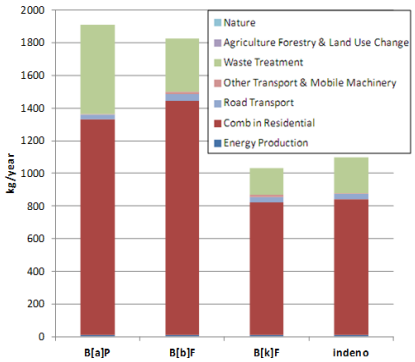

Figure 3. *Contribution of the emission sectors to PAHs emission over Lazio Region.*

Over Rome Province there is an increase of non industrial heating contribution that reaches an average contribution of 87%, varying from the 84% of B[a]p to the 89% of B[b]f emissions. The contribution of Road Transport is almost the same, in absolute terms, over the Region and the Province domains, probably because the largest part of Lazio Region road network of is concentrated around (and within) Rome city.

The processing system Emission Manager (EMGR) has been used to perform space and time disaggregation (Calori et al., 2007) and prepare model-ready gridded emissions. Spatial disaggregation uses cartographic support to locate each emission category within the municipality territory, while time variation is modelled assigning monthly, weekly and hourly modulation profiles to specific source categories. Figure 4 shows the space distribution of total yearly PAHs emission over Rome metropolitan area.

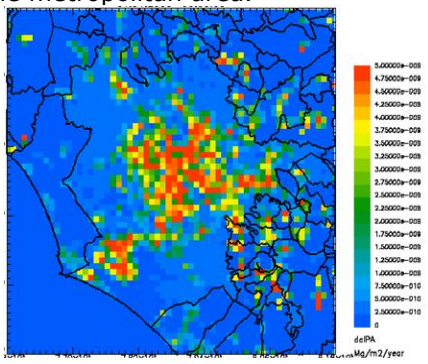

Figure 4. *Total PAHs yearly emission over Rome metropolitan area.*

References

Calori G., Finardi S., Nanni A., Radice P., Riccardo S., Bertello A. and Pavone F. (2007) Long-term air quality assessment: modeling sources contribution and scenarios in Ivrea and Torino areas", Environmental Modelling and Assessment, 13, 329–335

Integration of PAH atmospheric processes within FARM model

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The current version of FARM (Flexible Air quality Regional Model), implementing the *SAPRC99* gas-phase chemical mechanism and the *AERO3* aerosol module, has been extended to the following four indicator compounds for PAHs: benzo(a)pyrene (B[a]P); benzo(b)fluoranthene (B[b]F); benzo(k)fluoranthene (B[k]F) and indeno(1,2,3-cd)pyrene (I_P). Reactions of these PAHs with hydroxyl radical and their partitioning between gaseous and particulate phase, considering both adsorption and absorption (by organic aerosol and water) processes (Aulinger *et al.*, 2007), have been included in a newer version of the model that has been applied over Italy, at 20 km horizontal resolution, for the year 2005 (Silibello *et al.,* in press).

This application of FARM, performed in the frame of the MINNI Project (http://www.minni.org/) funded by the Italian Ministry of Environment, Territory and Sea, has been performed using meteorological fields produced by the prognostic, non-hydrostatic meteorological model RAMS, emission data derived from national and European inventories and boundary conditions extracted from EMEP models (MSC-E and MSC-W) output. The analysis of model results has then been focused on B[a]P, considered a marker substance for PAHs. In the following figure B[a]P yearly averaged concentration maps, computed by FARM and EMEP models, are presented.

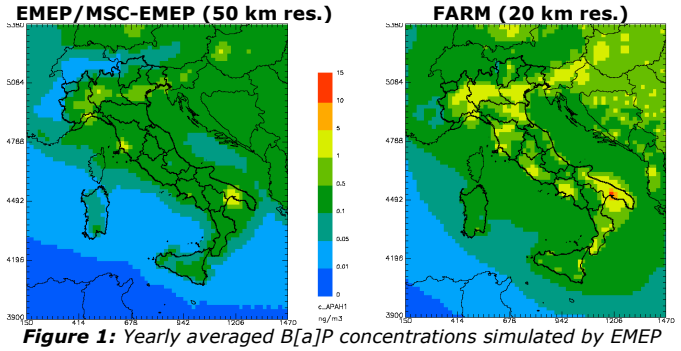

Figure 1: *Yearly averaged B[a]P concentrations simulated by EMEP (MSC-E) and new version of FARM for year 2005.*

The proposed comparison evidences larger values estimated by FARM, particularly in areas characterised by significant urban and industrial emissions. This could be attributed to: the higher resolution adopted by the national modelling system, the greater Italian emissions estimated by the national inventory and the effects induced by the use of a high resolution topography on meteorological fields and thus on the dispersion of pollutants. To evaluate the performance of FARM model, monthly averaged concentrations have been compared with available observations and EMEP/MSC-E results. This analysis has been focused on "background" sites more appropriate for the spatial resolution adopted in the simulations. The following figure 2 presents the available stations location that, due to the scarcity of data, is actually limited to the Po Valley (with the exception of one urban station. Cinecittà. located in Rome).

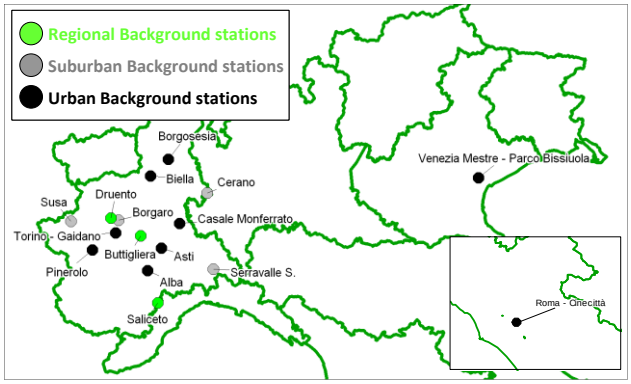

Figure 2: *Location of B[a]P background monitoring stations.*

The mentioned comparison (Figure 3) evidences the capability of the national modelling system to capture the seasonal behaviour of B[a]P; to provide better results than those estimated by the continental scale EMEP/MSC-E model and to reproduce the observed spatial distribution and temporal variability of concentrations, with some exceptions possibly due to the adopted model resolution, uncertainties in emission inventories and measurements representativeness.

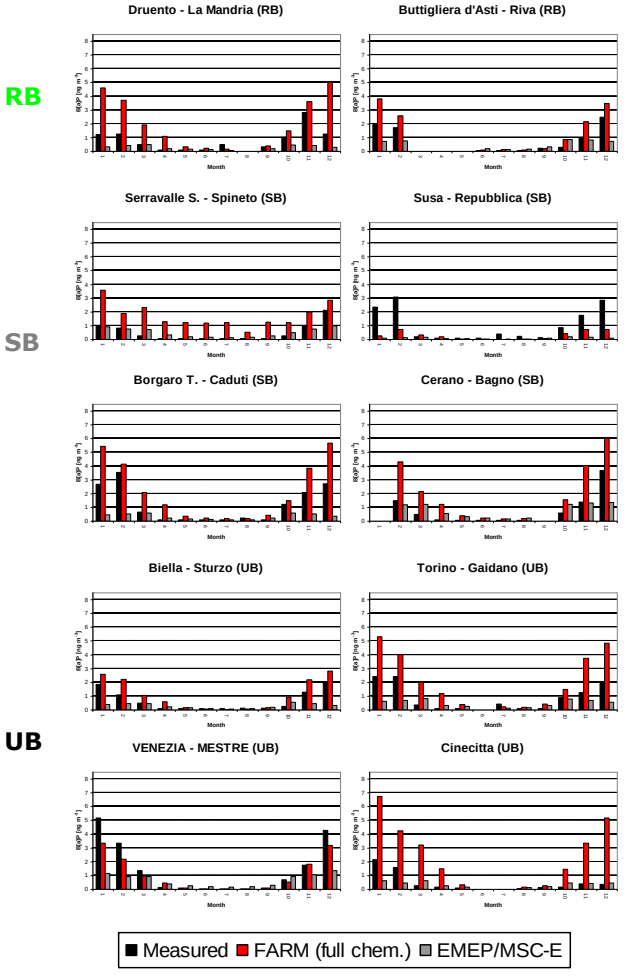

Figure 3: Observed and computed monthly B[a]P concentrations at background stations (RB: regional, SB: suburban; UB: urban).

References

*Aulinger, A., Volker M., Quante M. (**2007**) Introducing a Partitioning Mechanism for PAHs into the Community Multiscale Air Quality Modeling System and Its Application to Simulating the Transport of Benzo(a)pyrene over Europe. Journal of Applied Meteorology and Climatology, 46, 11, 1718-1730.*

*Silibello, C., Calori, G., Costa, M. P., Dirodi, M., Mircea M., Radice, P., Vitali L., Zanini G. (**in press**) Benzo[a]pyrene modelling over Italy: comparison with experimental data and source apportionment. Accepted for publication in the Special Issue "Science in Support of International Treaties on POPs" of Atmospheric Pollution Research.*

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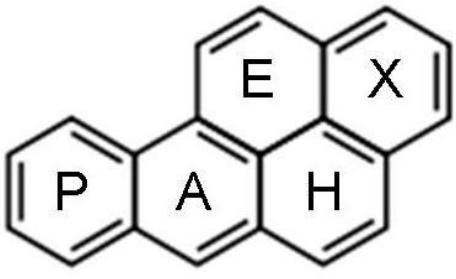

EXPAH Factsheet

Project title	Population exposure to PAH
Project acronym	EXPAH
Duration of the project	1/10/2010 – 31/12/2013
Total project budget	2,037,749 €
EC financial contribution	978,202 € (= 49.98 % of total eligible budget)

EXPAH Partners

Department of Epidemiology Lazio Regional Health Service

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Incoming activities

- Mid-Term EXPAH conference December 18th 2012 at the INAIL Institute located at via Urbana 167 Rome.
- Finalization of meteorological simulations in the national and target domains
- Starting of PAHs, $PM_{2.5}$ and gaseous pollutants simulations in the target domains.
- Finalization of winter and summer indoor/outdoor PAHs chemical analysis, data sets and technical reporting
- Finalization of summer PAHs personal exposure measurements and their chemical analysis.
- Starting of statistical analysis of winter and summer indoor/outdoor PAHs and $PM_{2.5}$ data