Population Exposure to PAH EXPAH

EXPAH ENV/IT/000082 October 2013, Issue 4

Welcome to 4th issue of the Newsletter

Editorial

The EXPAH partners are pleased to present the fourth issue of the EXPAH 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@deplazio.it**).
In this number a brief introduction to the latest results delivered by the EXPAH project is given. The indoor/outdoor monitoring results of VOCs, O_3 and NO_2 in schools, homes and offices, are presented. A statistical analysis of indoors infiltration of PAHs and $PM_{2.5}$ is here presented. A modeled estimation of PAHs lung deposition is then presented to provide an assessment of the dose uptake by elderly and children. A time activities and microenvironments based modeling approach to estimate the population exposure to PAHs and $PM_{2.5}$ is then shown with its results. Then the seasonal PAHs concentrations and diagnostic ratios are presented. Finally an application of Machine Learning methods to optimize PAHs Chemical Transport Model results is shown.

The LIFE+ EXPAH Project

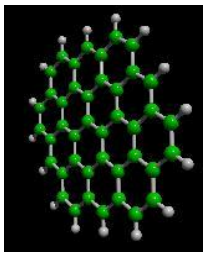
The European Community funded a project (EXPAH) by means of LIFE financial instrument, with the aim to identify and to quantify population exposure among children and elderly people to Polycyclic Aromatic Hydrocarbons (PAHs) content in particulate matter in highly urbanized areas and to assess the impact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

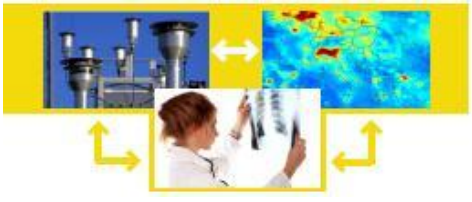
An integrated project: The project is based on an integrated approach where measurements, modeling techniques and epidemiologic investigations will be used to obtain estimation maps of population exposure to PAHs, to identify key determinants of high exposures including time-activity and locations in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





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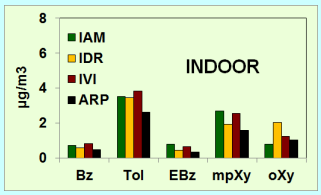
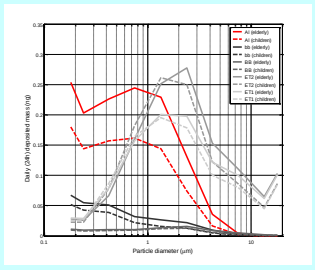
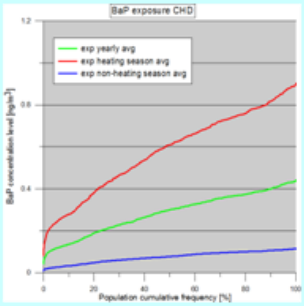






EXPAH Progress Status

The LIFE+ EXPAH project has reached the 37 months of lifetime.

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

- Finalization of the statistical analysis of indoor/outdoor PAHs and $PM_{2.5}$ and corresponding I/O ratios
- Developing of a lung deposition modeling for children and elderly people
- Finalization of a microenvironment infiltration model
- Finalization of the developing of an exposure model based on time-activity data and microenvironments infiltration factors
- Identification of emission scenarios on planned or future local, National and EU policies for PAHs
- Start of model simulations of PAHs, $PM_{2.5}$ and gaseous pollutants in the identified emission scenarios
- Start of an optimization modeling study, based on a machine learning method and Neural Network technique, to obtain better agreement between measured and modeled PAHs concentrations
- Analysis of mortality data and hospital admissions in Rome during the studied year.

Recent Reports

- Report on infiltration and exposure model with software prototypes http://www.ispesl.it/expah/documenti/Report%20on%20infiltration%20and%20exposure%20model%20with%20software%20prototypes%20Actions%205.1-5.3.pdf
- Evaluation of policy and mitigation scenarios (Action7.1) http://www.ispesl.it/expah/documenti/R2013-14_ARIANET_EXPAH_A7.1_final.pdf
- Indoor/Outdoor monitoring of PAHs, PM2.5 and its chemical components with ancillary measurements of gaseous toxicants:
  extended technical report
  http://www.ispesl.it/expah/documenti/Technical_Report_CNR_INAIL_2012h%20finale.pdf
  short technical report
  http://www.ispesl.it/expah/documenti/Short_TR_CNR_INAIL_2012m_FINALE%20ver1.pdf
- FARM model capability to simulate PM2.5 and PAHs in the base case (Action 4.5) http://www.ispesl.it/expah/documenti/R2013-06_ARIANET_EXPAH_A4.5_final.pdf
- Time activity pattern of children and elderly in Rome (action 3.1) http://www.ispesl.it/expah/documenti/Survey%20on%20children%20and%20elderly%20people%20time%20activity%20in%20Rome-action%203.1.%20final%20report.pdf
- Technical report on meteorological measurements (action 3.4). http://www.ispesl.it/expah/documenti/Technical%20report%20on%20meteorological%20measurementsrev1.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
- 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

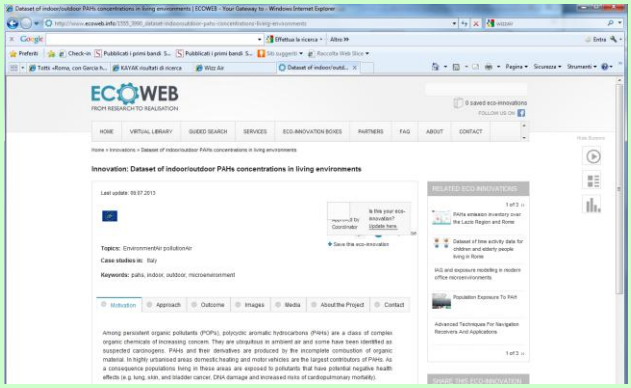
Recent presentations and publications

- *Eurotox Conference* - 49th Congress of the European Societies of Toxicology, Interlaken, Switzerland 1st-4th September 2013.
  Exposure to PM2.5-bound PAHs in Rome: the contribution of transportation microenvironments.
  http://www.ispesl.it/expah/documenti/Poster_Eurotox_CARS%20AND%20BUS.pdf
  Urban air pollution in Rome: children and elders exposure to PAHs in fine particulate matter (PM2.5)
  http://www.ispesl.it/expah/documenti/Poster_Eurotox_Children%20and%20elders_Monica.pdf
- *European Aerosol Conference (EAC)*, Prague, 1-6 September, 2013.
  Aerosol Processes in PAH Infiltration and Population Exposure in Rome (EXPAH)
  http://www.ispesl.it/expah/documenti/Lipponen-abstract-eac-2013.pdf
  Seasonal behavior of indoor and outdoor PAHs in different microenvironments of Rome, Italy
  http://www.ispesl.it/expah/documenti/EAC_Seasonal%20behavior.pdf.pdf
- *33rd International Technical Meeting (ITM) on Air Pollution Modelling and its Application*, 26-30 Agosto, 2013, Miami, Florida USA.
  http://www.ispesl.it/expah/documenti/33rd_ITM_Claudio_Gariazzo.pdf
- *Environment and Health – Bridging South, North, East and West. Conference of ISEE, ISES and ISIAQ*, Basel, Switzerland, 19-23 August 2013
  http://www.ispesl.it/expah/documenti/Lipponen_etal_2013_Basel_PAH_io_relationship_and_exp_levels_in_Rome_v6.pdf
- *Workshop su progetto EXPAH: stato di avanzamento e risultati disponibili*. Organizzato da Arpa Friuli V. G.; Palmanova 5 Luglio 2013.
  Stima delle emissioni di IPA e simulazioni modellistiche in ambito EXPAH:
  http://www.ispesl.it/expah/documenti/Expah_ARPA-FVG_05072013_finardi.pdf
  Il progetto LIFE+ EXPAH- Attività di monitoraggio PAHs:
  http://www.ispesl.it/expah/documenti/EXPAH_monitoraggio.pdf
  Metodologia EXPAH per lo sviluppo di un modello di esposizione della popolazione a PAHS:
  http://www.ispesl.it/expah/documenti/modello%20di%20esposizione_gariazzo.pdf
- *XIV Congresso Nazionale della Divisione di Chimica dell'Ambiente e dei Beni Culturali*, Rimini 2-5 giugno 2013
  Studio dell'esposizione di bambini e anziani a Idrocarburi Policiclici Aromatici (IPA) presenti nel particolato sottile della città di Roma: http://www.ispesl.it/expah/documenti/Abstract%20SocChimIta.pdf

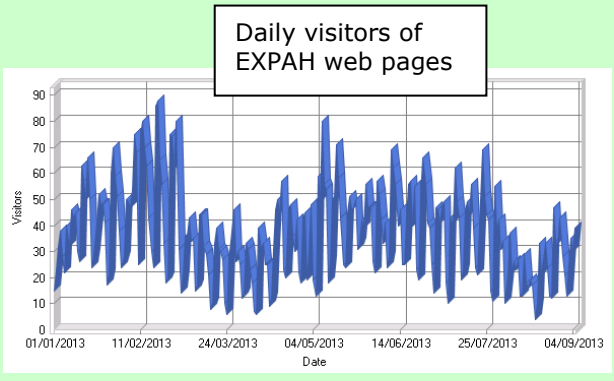
Achieved milestones and deliverables

- Kick-off EXPAH meeting
- Website finalisation
- Mid-Term EXPAH conference
- Simulation of PAHs emission, dispersion, transformation in the base case scenario
- Infiltration and exposure model with software prototype
- Finalisation of a model ready PAHs emission inventory
- Data sets of meteorological data,
- Data sets of indoor/outdoor $PM_{2.5}$, PAHs and PM components in living places
- Data sets of personal exposure to $PM_{2.5}$ and PAHs
- Report on evaluation of policy and mitigation

Dissemination activities

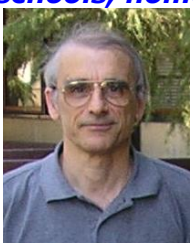


Web dissemination on ECOWEB portal



Attended Scientific Conferences	
XIV Congresso Nazionale di Chimica dell'Ambiente e dei Beni Culturali	12° SIGMA ALDRICH YOUNG CHEMISTS SYMPOSIUM - S.A.Y.C.S.
Ecomondo	ITM 2013 NATO/SPS International Technical Meeting on Air Pollution Modeling and its Application
Environment and Health – Bridging South, North, East and West. Conference of ISEE	European Aerosol Conference
49th Congress of the European Societies of Toxicology	

VOCs, O_3 and NO_2 in spring/summer at the schools, homes and offices of Rome



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In the frame of Life+ EXPAH project airborne volatile hydrocarbons were evaluated by means of diffusive sampling and GC-FID analysis.
Three schools, four homes and an office were the sites of study; similarly to PAHs the volatile hydrocarbons (mono-aromatics) were monitored both indoors and outdoors from May 14th to June 1st, 2012.

Results

A. BTEX

Fig. 1 shows the mean BTEX (benzene (Bz), toluene (Tol), ethyl-benzene (EBz), *ortho*-xylene (oXy) and *meta/para*-xylene (mpXy)) recorded at the schools (IAM, IDR, IVI) and the office (ARP).

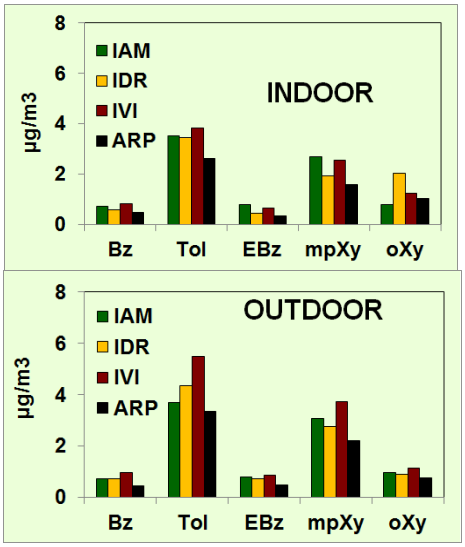

Fig. 1 – *Average BTEX recorded at schools and the office in spring*

According to these values, at schools the in/out ratio ($R_{i/o}$) was, on the average, <1.0 (i.e., ≈0.82) for all compounds except o-xylene ($R_{i/o}$ = 1.38) (see Table 1). At office, $R_{i/o}$ exceeded unity for benzene and o-xylene (reaching 1.11 and 1.35, respectively), whilst it was < 0.8 for toluene, ethylbenzene and *m/p*-xylene.

Table 1 – *Indoor/outdoor concentration ratios of volatile hydrocarbons at schools and an office (ARP) in spring*

IN/OUT	Bz	Tol	EBz	mpXy	oXy
ARP	1.11	0.78	0.69	0.72	1.35
IAM	1.03	0.95	0.97	0.88	0.82
IDR	0.80	0.80	0.61	0.70	2.23
IVI	0.85	0.70	0.75	0.69	1.09

The period average burdens of BTEX in the air at homes in summer (Jun. 28–Jul. 19, 2012) are shown in Fig. 2. According to them, total BTEX were higher at homes than at schools and office. Also the in/out ratios were different. $R_{i/o}$ was, on the average, >1 for Bz, Tol and EBz, and <1 for xylenes (see Table 2).

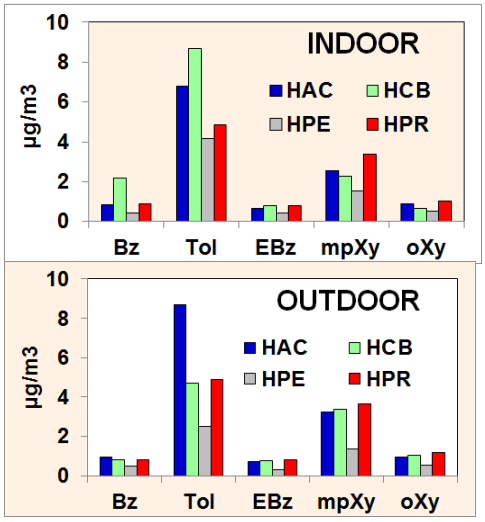

Fig. 2 – *Average BTEX recorded at homes in summer*

Table 2 – *Indoor/outdoor concentration ratios of volatile hydrocarbons at homes in summer*

IN/OUT	Bz	Tol	EBz	mpXy	oXy
HAC	0.88	0.78	0.94	0.78	0.94
HCB	2.73	1.84	1.01	0.67	0.65
HPE	0.94	1.67	1.45	1.14	0.93
HPR	1.11	0.99	0.97	0.92	0.86

B. Ozone and Nitrogen Dioxide

Concurrently with BTEX, nitrogen dioxide and ozone were monitored by diffusive sampling and IC analysis. The results for schools, office, and homes, are shown in Tables 3-4, respectively.

Table 3 – *Average indoor and outdoor concentrations of NO_2 and O_3 at schools and office in spring*

µg/m³	NO_2 in	NO_2 out	O_3 in	O_3 out
ARP	27	44	14	90
IAM	46	39	23	74
IDR	42	41	28	69
IVI	46	54	32	75

Table 4 – *Average indoor and outdoor concentrations of NO_2 and O_3 at homes in summer*

µg/m³	NO_2 in	NO_2 out	O_3 in	O_3 out
HAC	51	57	13	64
HCB	37	40	20	70
HPE	24	22	62	87
HPR	42	46	27	67

O_3 was all-the-time lower indoors than outdoors, independently from site. By contrast, indoor NO_2 values was usually close to outdoors ones, with important exceptions at IAM and HPE home.

References

Indoor/Outdoor monitoring of PAHs, PM2.5 and its chemical components with ancillary measurements of gaseous toxicants:
http://www.ispesl.it/expah/documenti/Technical_Report_CNR_INAIL_2012h%20finale.pdf

Analysis of infiltration of PAHs and $PM_{2.5}$ indoors

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Analysis of PAH exposures, based on the microenvironmental measurements over seasons (see Cecinato et al. 2013 and EXPAH Newsletter #3) confirmed that PAHs of outdoor origin dominate the indoor levels. There is statistically significant evidence on the contribution of indoor sources, but the magnitude of the contributions are close negligible in comparison with the outdoor originating part. Therefore analysis of infiltration of PAH compounds is a central element in developing an exposure model for children and the elderly.

Previous analyses on $PM_{2.5}$ have demonstrated a clear seasonal trend in infiltration, peaking in summer and having the lowest values in mid-winter, explained by the ventilation, opening windows and energy savings behaviour of building managers and occupants (Hänninen et al., 2011). Therefore it was of interest also to look at the EXPAH measurements whether such trends could be observed.

Data was analysed also in terms of understanding whether the buildings for different microenvironments, such as homes, schools and offices, would have differences in the infiltration. However, the observed infiltration factors were not statistically significantly different in most cases.

Fig 1. shows the observed i-o ratios at homes for benzo(a)pyrene (BaP), the most significant PAH compound in terms of mass concentrations and carcinogenicity. In comparison with the corresponding data for $PM_{2.5}$ (Fig 2.), it can be seen that while for $PM_{2.5}$ indoor sources are much more common and more important in terms of concentrations, the infiltration rates do not differ with statistical significance.

Indication of statistical significance was observed for indoor sources and for differences between (a) BaP infiltration at homes in summer time (p=0.03) (b) $PM_{2.5}$ infiltration at homes in summer and in non-heating season and (c) between several individual PAH compounds. The latter finding could not be explained by the observed differences in the compound specific particle size distribution and requires confirmation by further analysis in the future.

The results of the analyses are described in more detail in the technical report (Lipponen et al., 2013).

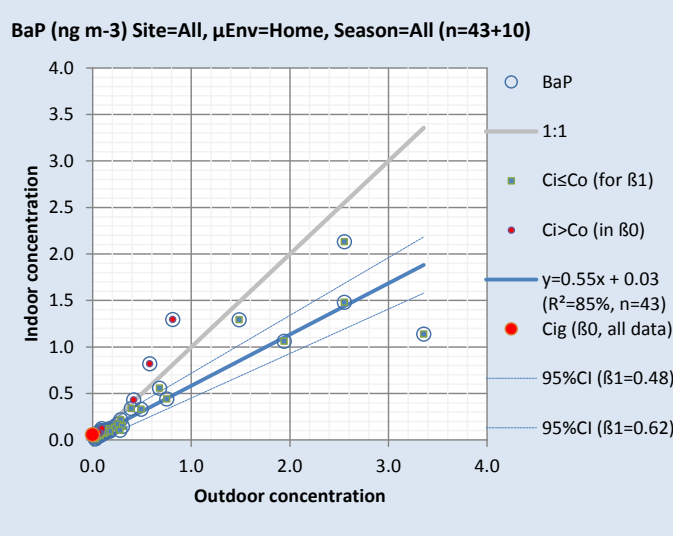

Fig. 1. *Benzo(a)pyrene i-o ratios at the measured homes. In 43 cases out of 53 the indoor levels were lower than outdoor levels. The infiltration rate over all seasons covered (winter, spring and summer) was 0.55±0.07.*

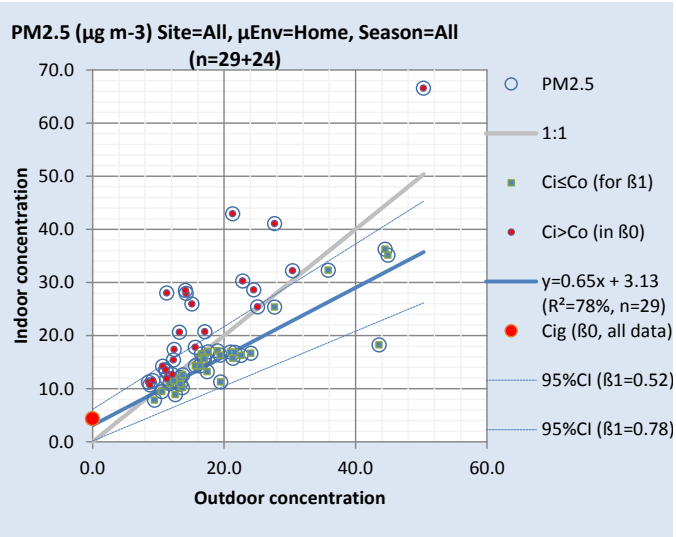

Fig 2. *Indoor sources for PM2.5 were substantially more common (red dots) than for any of the PAH compounds. The mean infiltration rate (0.65±0.13) was not statistically significantly different from the corresponding BaP value.*

References

Cecinato A, Romagnoli P, Balducci C, Guerriero E, Perilli M, Vichi F Imperiali A, Perrino C, Tofful L, Sargolini T, Catrambone M, Dalla Torre S, Rantica E, Gherardi M, Gatto MP, Gordiani N, L'Episcopo N, Gariazzo C, Sacco F, Sozzi R, Troiano F, Barbini F, Gargaruti C, Bolignano A., 2013. EXPAH Action 3.3: Extended Technical Report on Indoor/Outdoor monitoring of PAHs, PM2.5 and its chemical components with ancillary measurements of gaseous toxicants in the frame of the EXPAH Project. 214 pp. http://www.ispesl.it/expah/documenti/Technical_Report_CNR_INAIL_2012h%20finale.pdf (accessed 2013-07-04)

Hänninen O, Hoek G, Mallone S, Chellini E, Katsouyanni K, Kuenzli N, Gariazzo C, Cattani G, Marconi A, Molnár P, Bellander T, Jantunen M, 2011. Seasonal patterns of outdoor PM infiltration into indoor environments: review and meta-analysis of available studies from different climatological zones in Europe. Air Qual Atmos Health 4(3-4):221-233. DOI: 10.1007/s11869-010-0076-5 http://www.springerlink.com/content/k26h4563110m373g/fulltext.pdf (accessed 2011-08-31)

Lipponen P, Sorjamaa R, Hänninen O, 2013. Infiltration and exposure model with software prototypes. Project report of Life+ EXPAH (Contract ENV/IT/000082; 2009), 50 pp.

Lung PAHs deposition modelling

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Health impacts of particulate matter air pollution are caused by actual uptake of the particles by the human respiratory tract (Fig. 1). Particles that are removed from the indoor air by buildings (step 1 in Fig 1) and particles that are not deposited in the lung (step 2) do not presumably affect the health of the subjects. As these processes are strongly dependent (Fig. 2; Hänninen et al., 2013).

Even though this was not included in the original research plan of EXPAH, which concentrated on understanding the microenvironmental concentrations and exposures, parallel developments in the modelling at THL and the valuable measurements of PAH particle size distributions allowed us to conduct preliminary calculations also on the respiratory tract uptakes.

We applied the experimentally validated ICRP (1994) model for the calculation of particle deposition in the five regions of the human respiratory tract (extra thoracic 1 and 2, thoracic 1 and 2 and alveolar). The model was previously also evaluated against other mainstream respiratory tract models by W. Hofmann (2011) showing good correspondence between the models.

The ICRP (1994) model was implemented in matlab environment by Voutilainen et al. (2004). Daily activites were modelled according to the EXPAH diaries collected in Action 3.1 and it was assumed that the subjects were sleeping in the night, sitting while indoors during the day time, and walking while outdoors (i.e. light exercise). The breathing volumes specified for these activities in the ICRP manual were used together with the PAH particle size distributions measured at the MLI station in Rome. The results are presented for the sum of all 11 PAH compounds in Fig 2, but are available for each compound separately.

The results show that the uptake is slightly larger for the elderly, mainly due to their larger body size and consequent breathing rate, and occurs mainly in the extrathoracic (grey) and alveolar (red) regions of the lung (Fig. 2.).

It can be assumed that lung cancer risks are mainly caused by alveolar uptakes, as the upper respiratory tract regions are influenced by the ciliary clearance mechanism, which transports the particles to pharynx and the digestive tract. Allergic reactions are affected also by bronchiolar and extra thoracic doses. Furhter studies are needed to clarify the role of deposition regions for the health risks.

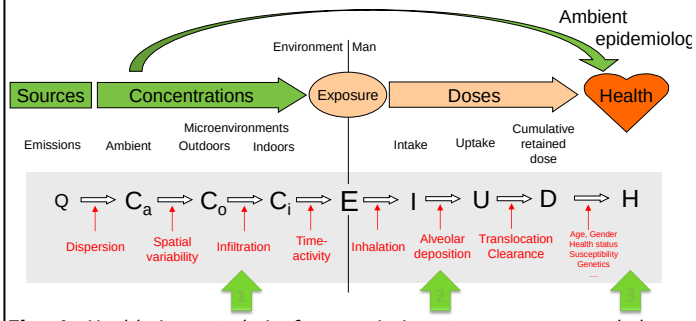

Fig. 1*. Health impact chain from emissions to exposures and doses, highlighting the steps affected by particle size especially (1)infiltration and (2) respiratory tract uptake.*

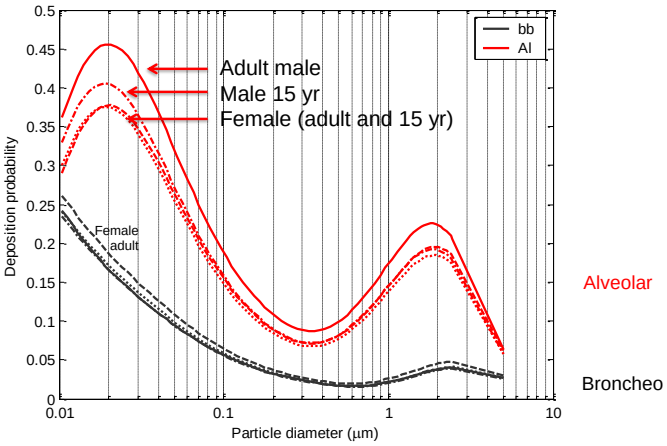

Fig. 2*. Dependency of respiratory tract uptake of particles on the particle diameter. (based on ICRP, 1994 model)*

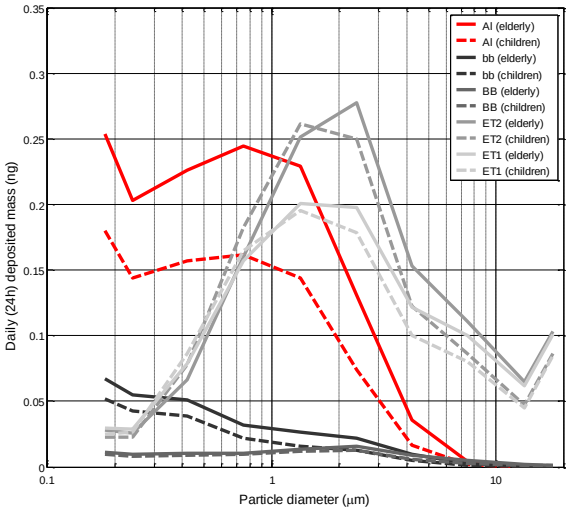

Fig 2. *PAHs mass taken up by various regions of the lungs of elderly (solid lines) and children (dotted lines).*

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Modeling of population exposure to PAHs in Rome

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In order to estimate PAHs exposure for the target population a newer version of the three-dimensional Eulerian chemical-transport model FARM (Flexible Air quality Regional Model), which includes the PAHs reactions with hydroxyl radical and their partitioning between gas and aerosol phases, has been applied to an high spatial resolution (1x1 Km^2) domain including the Rome conurbation. Simulations were carried out for one year period (June 2011-May 2012) to estimate gridded PAHs in both gaseous a aerosol phases.

Field campaigns carried out indoor and outdoor particulate PAHs and $PM_{2.5}$ concentrations which were measured in schools, homes, offices and commuting vehicles microenvironments. These measures were used to evaluate outdoor/indoor infiltration factors for each microenvironment.

Time activities data were collected from a statistical survey carried out for the target population living in Rome, according to type of days (workday; weekend), season (autumn-winter; spring-summer) and microenvironment visited.

In the frame of Action 5.3 of EXPAH project, by availing these results, a microenvironments exposure model for PAHs was developed. It calculates exposures of children and elderly people according to the time spent in different environments (indoors, outdoors, in traffic and living ambient).

The general approach for exposure estimation can be expressed by the following:

$$\mathrm{Exp}_i = \sum_{j=1}^{n} C_j t_{i,j}$$

Where Exp_i is the total exposure for person i over the specified period of time; C_j is the pollutant concentration in each microenvironment j and $t_{i,j}$ is the time spent by the person i in microenvironment j.

Figure 1 shows exposure to B[a]P of target population investigated.

Seasonal PAHs and B[a]P exposure maps has been carried out for heating season (November-March) and non-heating season (April-October); results are presented in Figure 2.

Since the exposure assessment requires the relation between concentration and density of population, exposure population profiles were obtained by matching exposure maps with density population maps, Figure 3 presents children exposure profiles to PAHs and B[a]P.

Finally, the validation of the model was produced by comparing PAHs exposure measurements of target population monitored on six volunteers living in different areas of Rome with modeled exposure results.

Figure 4 shows an example of comparison between model exposure results with personal exposure measurement.

Modeling results:

PAHs exposure results show that the model is able to reproduce the mean seasonal behavior of exposure.

There are no remarkable differences between children and elderly exposure and its values are higher during heating season; this suggests that cold season combustion is probably the main source of population exposures in Rome.

Agreement was found with personal PAHs exposure data, although the day-by-day variations were poorly reproduced.

The yearly BaP exposure was found lower than legal limit, although during the colder seasons an exceedance is foreseen for most parts of the city.

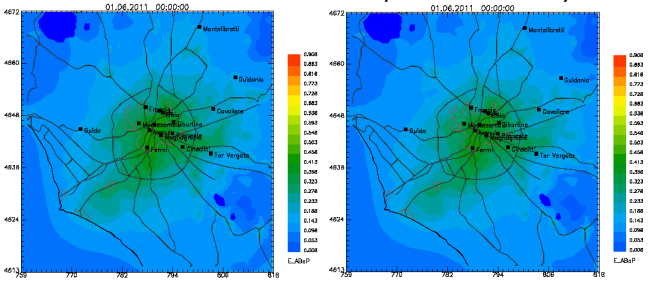


Figure1. *Annual B[a]P exposure maps.Children (left), Elderly (right)*

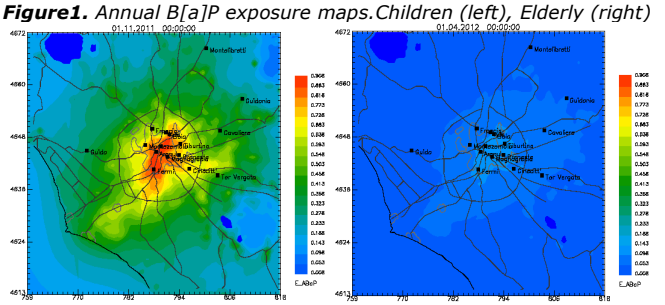
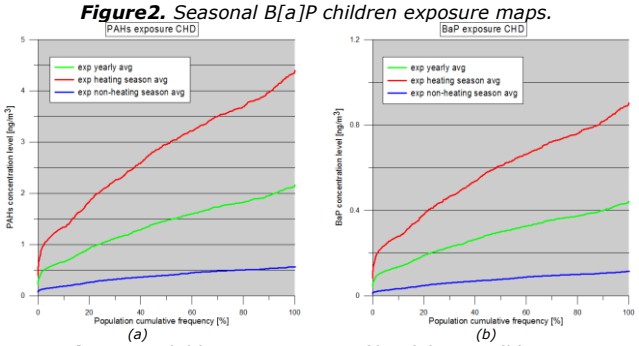


Figure2. *Seasonal B[a]P children exposure maps.*



(a) *(b)*

Figure3. *Children exposure profiles (a) PAHs (b) BaP.*

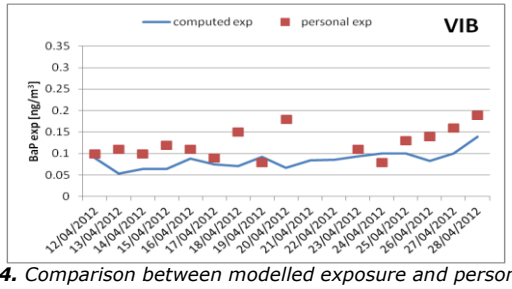


Figure4. *Comparison between modelled exposure and personal VIB (child) volunteer exposure.*

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Seasonal variation of PAHs concentrations and diagnostic ratios in Rome conurbation

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EXPAH field campaigns have been carried out from November 2011 to July 2012 in both indoor and outdoor environments. The monitoring involved 17 locations (nine houses, six schools and two offices), together with three stations of the urban air quality network. The large number of samples allowed to quantify a seasonal variation of more than one order of magnitude for heavy PAH congeners concentration, with B[a]P varying between min-max values of 0.01-3.0 ng/m^3 recorded during summer and winter months. Figure 1 shows B[a]P, B[b]F, B[k]F and IP average concentrations for each sampling period. The time variation of PAHs concentration is much larger than that of $PM_{2.5}$ mass concentration of the corresponding samples indicating the possible contribution of different sources along the year. A large variation of concentrations is observed even for contiguous winter sampling periods, when B[a]P average concentrations ranges between 2-3 ng/m^3 during polluted periods, and 0.5 ng/m^3 during "clean" periods.

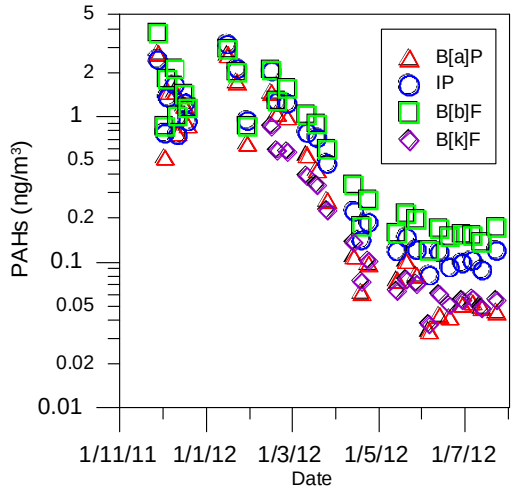

Figure 1. PAHs concentrations averaged over each field campaign.

The space variability of PAHs concentrations, evaluated by the coefficient of variation (the ratio of the standard deviation to the mean) over the different sampling stations for each sampling period, is larger during summer than in winter, with average seasonal values respectively of 0.4 and 0.2 for B[a]P (Figure 2).

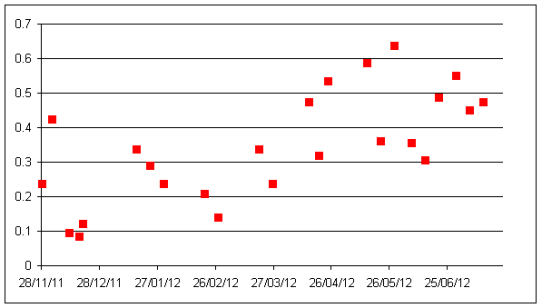

Figure 2. B[a]P concentration standard deviation divided by the mean for each field campaign.

The identification of specific sources footprint has been attempted by analyzing the ratios of individual PAH concentrations with the approach indicated by Ravindra et al. (2008). In particular, we analyzed the seasonal variation of B[a]P/B[ghi]P, IP/(IP+B[ghi]P), B[b]F/B[k]F, B[a]P/(B[a]P+CH) and B[a]A/(B[a]A+CH). All the diagnostic ratios show a continuous and nearly linear variation from winter to summer with values indicating the presence of a multiplicity of sources influencing the Rome area, with different relative contributions during the year. The sources contribution variation is synthesized in Figure 3 by the cross plot B[a]A/(B[a]A+CH) vs. IP/(IP+B[ghi]P), which indicates the relevance of sources connected to house heating and possibly biomass burning during winter and the prevailing contribution of petroleum combustion and road traffic during summer.

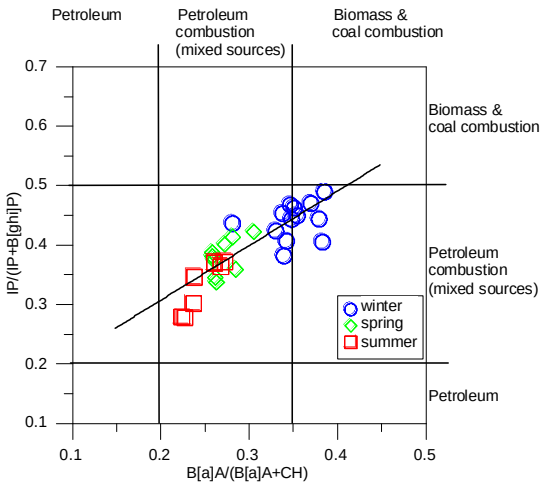

Figure 3. B[a]A/(B[a]A+CH) vs. IP/(IP+B[ghi]P) cross plot.

A similar picture is provided by the B[a]P/B[ghi]P ratio, which indicates the relatively higher concentration of B[a]P recorded during wintertime (Figure 3).

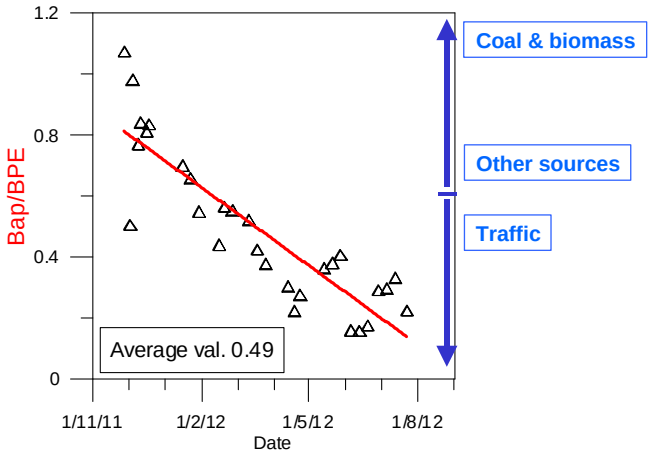

Figure 4. B[a]P/B[ghi]P concentrations ratio averaged over each field campaign.

The mentioned sources influence is confirmed by the comparison of diagnostic ratios with emission profiles measured during the latest years in Italy by CNR/IIA for mobile and industrial sources, and by some of the emission profiles available in literature (see e.g. Ravindra et al., 2008). The seasonal variation of diagnostic ratios shows that yearly average values are not suitable for source attribution in urban areas.

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Application of Machine Learning methods to optimize PAHs model results

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The goal of action 5.5 is to use machine learning methods (i.e. Support Vector Machines and Artificial Neural Networks) to build daily exposure maps of PAH, BaP and $PM_{2.5}$ on the urban area of Rome to improve the results achieved by deterministic models (action 4.5).
Machine learning methods are a branch of the artificial intelligence and they are mainly applied to classification and regression problems.
Given a system and some samples, their purpose is learning the relations between inputs and outputs, through an adaptive learning process, to build forecasting models.
We used concentrations measurements of these pollutants in different locations of the area of interest and in different periods between June 1, 2011 and May 30, 2012 (obtained in action 3.3).
For each data sample, we used the modeled values of wind speed and direction, pressure, precipitations, relative humidity, temperature, total cloud cover, emissions and pollutants concentrations provided by the Chemical Transport Model (CTM) FARM, as well as the dates of the measurements and the geographical coordinates of the measurement stations.
So, our purpose is to build a forecasting model which takes as inputs the values of the above variables and outputs a better estimation of the pollutants concentration than that provided by the CTM model.
At the moment, we have mainly used Support Vector Machine (SVM) methods.
In order to understand which input variables achieve the best model results, we have carried out many simulations, building models with different input variables schemes.
For each simulation, first we have randomly split the whole data set into a training set (~70%) and a test set (~30%). The former was used for the training phase (i.e. for building the model), while the latter only to assess the model capability to reproduce the outputs.
We did that because we are mainly interested in understanding how much the model is able to generalize, i.e. to reproduce correctly data it has never seen before.
In Table 1 and 2, the results of the different models are shown in term of different criteria: mean absolute error (MAE), the slope of the trading line passing through the origin (α) and R^2. The highlighted lines in the following tables refer to the best simulations.
Furthermore, we have carried out some simulations using Artificial Neural Networks, obtaining results very similar to those achieved by SVMs.

PAH - TEST SET (55 samples)						
Input variables				Results		
Date	Meteo	Emissions	FARM	MAE (ng/m³)	R^2	α
	x			0.78	0.87	0.90
	x	x		0.65	0.90	0.95
	x	x	x	0.67	0.91	0.94
	x		x	0.71	0.90	0.87
x	x			0.58	0.94	0.93
x	x	x		0.62	0.92	0.95
x	x	x	x	0.60	0.93	0.93
x	x		x	0.64	0.92	0.86

Table 1 *Results of PAH simulation by SVM*

BaP - TEST SET (55 samples)						
Input variables				Results		
Date	Meteo	Emissions	FARM	MAE (ng/m³)	R^2	α
	x			0.22	0.79	0.91
	x	x		0.24	0.75	0.92
	x	x	x	0.24	0.74	0.88
	x		x	0.23	0.76	0.89
x	x			0.20	0.80	0.88
x	x	x		0.22	0.77	0.88
x	x	x	x	0.21	0.79	0.87
x	x		x	0.20	0.77	0.86

Table 2 *Results of BaP simulation by SVM*

In order to evaluate better the models capability in reproducing "unknown" data, we have also tried to remove from the original data set a subset of samples of stations located in different parts of the area, to use them as test set, and we have obtained very satisfying results. An example of how good the model reproduce these data is shown in the following graph.

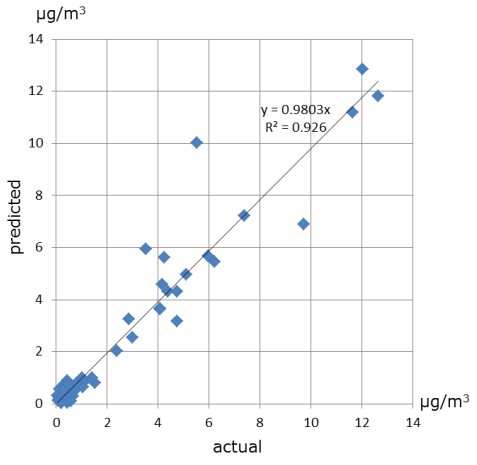

Figure N. 1 *Results of PAH simulation by SVM on a subset of stations located in different parts of the area.*

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EXPAH Factsheet

Project title	Population exposure to PAH
Project acronym	EXPAH
Duration of the project	1/10/2010 – 30/06/2014
Total project budget	2,037,749 €
EC financial contribution	978,202 € (= 49.98 % of total eligible budget)

EXPAH Partners

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Ongoing and Incoming activities

- Optimization of PAHs model results with actual population exposure
- Evaluation of the short-term impact of PAHs and other pollutants on emergency hospital admissions
- Evaluation of the impact of long-term exposure in the occurance of lung cancer, coronary and cerebrovascular events
- Definition of possible emission scenarios from planned alternative future EU policies for PAHs and mitigation scenarios
- Calculation of outdoor PAHs and exposure maps in the selected scenarios
- Calculation of health effects for the selected scenarios