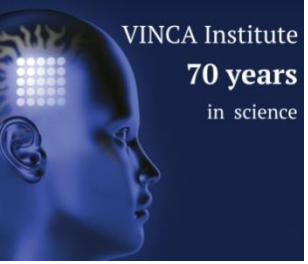


LABORATORY FOR THERMAL ENGINEERING AND ENERGY

4th Virtual International Conference on Science, Technology and Management in Energy

eNergetics 2018

# Health Risk of Polycyclic Aromatic Hydrocarbons – PAHs in Primary School Environment in Serbia, Probabilistic Modeling Study

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# Presentation outline

- Motivation;
- Introduction;
- Experimental measurements;
- Model features;
- Results;
- Conclusions and future work.

# Motivation - lung cancer is the most significant health effect from inhalation exposure to PAHs

- Polycyclic aromatic hydrocarbons (PAHs) are a group of organic compounds;
- Many of them are toxic and carcinogenic environmental contaminants;
- Air pollution is considered as a major cause for the world public health concern;
- Children represent one of the most susceptible groups with regard to air pollution.

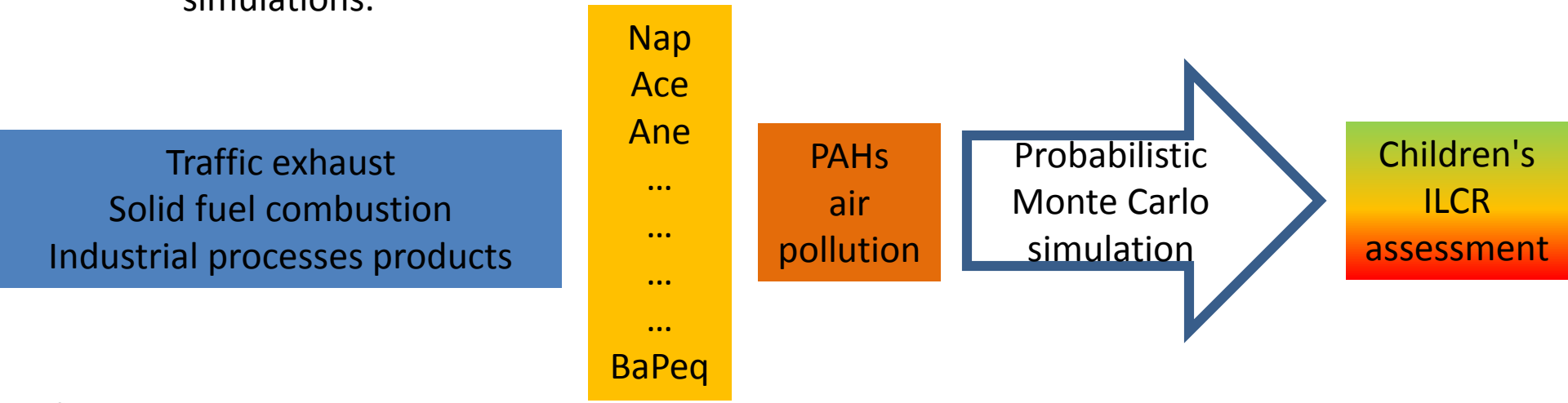
*https://woodsmokepollution.org/children.html

# Introduction – PAHs inhalation risk for children in Serbian schools

- Exposure to PAHs generally assumes exposure to a mixture of possibly toxic chemicals;
- Many of them are toxic and carcinogenic environmental contaminants;
- They typically result from the incomplete combustion processes of organic materials such as a wood, coal, petrol and diesel;
- In comparison with adults, children are more vulnerable to poor indoor air quality due to their still developing physiological and immunological systems, and greater inhaled breath per unit mass;
- In recent years, more and more scientific papers have been done on PAHs in schools in Europe;
- However, there are scarce information about cancer risks for children in Serbian schools.

# Introduction – Incremental lifetime cancer risk ILCR risk for children in Serbian schools

- Incremental lifetime cancer risk (ILCR) caused by long time humans' exposure to PAHs emissions is of special importance:
  - because of PAHs carcinogenic potential;
  - because their large emissions, especially in urban areas;
- The main objectives of this paper are:
  - experimental evaluation of concentrations of 16 priority PAHs in indoor and outdoor air in Serbian school where residential heating and traffic are the only major PAH sources;
  - calculation of cancer risk of PAHs for children from total suspended particles (TSP) using suggested incremental lifetime cancer risk (ILCR) model based on Monte Carlo simulations.



# Experimental measurement– measuring site description








- Zajecar is town located in the eastern part of Serbia;
- The town was developed mainly as agricultural center;
- It is populated by around 44000 inhabitants;
- Majority of households are heated by the individual heating stoves burning wood and coal;
- This significantly increases air pollution, and PAHs emissions;
- The school building, in which measurement campaign was conducted, is located in residential area;
- The school is 40 years old and the total number of students attending the school is around 750.

# Experimental measurement– procedure and equipment

- The sampling was conducted simultaneously in both indoor and outdoor environments;
- It lasted for full ten working days during April of 2012;
- Samples were collected using the low volume reference sampler for 24 hours period;
- The sampling flow rate was 2.3 $m^3$/h (38 L/min);
- 47 mm) quartz filters were used for sampling;
- After the sampling, the filters were extracted by acetone/hexane (1:1) mixture;
- Analysis was performed using GC-MS with a DB-5 MS capillary column;
- sixteen US EPA priority PAHs were determined: Nap), Ace, Ane, Flu, Phe, Ant, Fla, Pyr, BaA, Chy, BbF, BkF, BaP, DbA, BgP, and InP.


# Model description – main model features and inputs

- Monte Carlo simulation was used for probabilistic incremental lifetime cancer risk (ILCR) modeling;
- The main model feature is its ability to incorporate variability and uncertainty into risk assessment, thus providing more realistic view of long-time risk distribution.

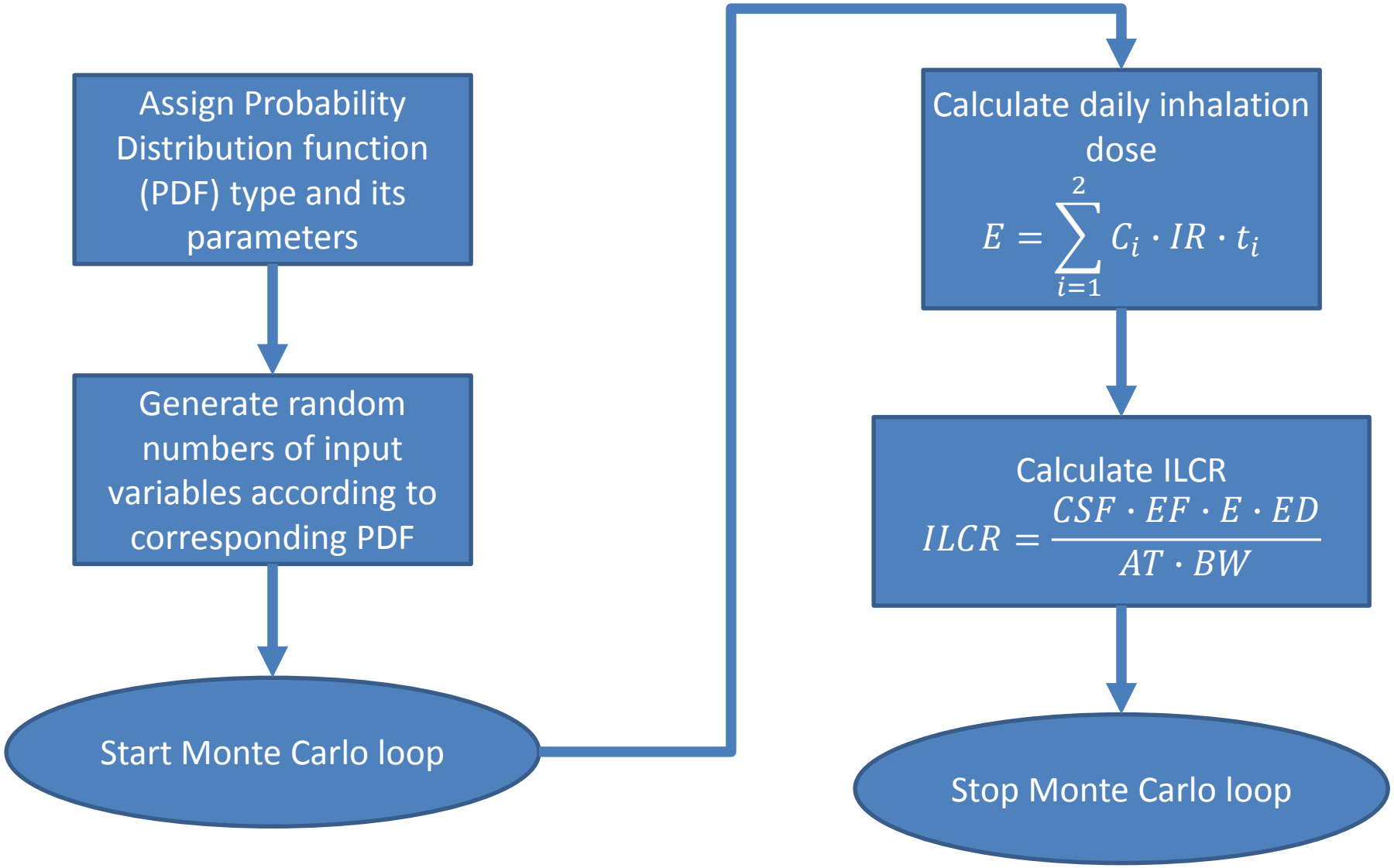
| Variable (measurement units) | Outdoor | Indoor | Distribution type |
|---|---|---|---|
| $C_i$ [ng·m$^{-3}$] | 9.29± 8.07 | 16.29± 14.7 | Log-Normal |
| IR [m$^3$·day$^{-1}$] | 9.98±1.83 | | Log-Normal |
| $t_i$ [h·day$^{-1}$] | 3 | 5 | Constant |
| CSF [kg·day·mg$^{-1}$] | 3.9 | | Constant |
| AT [days] | 25500 | | Constant |
| ED [years] | 3 | | Constant |
| BW [kg] | 32.5±7.1 | | Log-Normal |

Input Parameters for ILCR Calculations Using Monte Carlo Method.

| PAHs | Outdoor | Indoor | Outdoor/Indoor |
|---|---|---|---|
| Nap | 0.21±0.34 | 0.07±0.08 | 2.05±3.39 |
| Ace | 0.56±1.20 | 0.20±0.14 | 2.41±2.69 |
| Ane | 0.16±0.10 | 0.19±0.12 | 1.23±0.49 |
| Flu | 0.34±0.38 | 0.28±0.13 | 1.28±0.54 |
| Phe | 0.26±0.17 | 0.37±0.21 | 1.58±0.64 |
| Ant | 0.16±0.13 | 0.12±0.07 | 1.00±0.54 |
| Fla | 3.71±4.37 | 2.69±2.39 | 1.39±1.10 |
| Pyr | 4.09±4.70 | 3.25±2.89 | 1.10±0.72 |
| BaA | 6.83±6.80 | 6.95±7.50 | 0.90±0.64 |
| Chy | 8.24±7.92 | 8.32±8.84 | 0.87±0.60 |
| BbF | 5.98±4.87 | 9.10±8.36 | 1.27±0.88 |
| BkF | 4.66±3.72 | 7.71±7.73 | 1.28±0.78 |
| BaP | 5.60±4.90 | 10.48±9.50 | 1.66±1.07 |
| InP | 4.07±3.03 | 7.62±6.37 | 1.54±0.81 |
| DbA | 1.41±1.21 | 2.50±2.04 | 1.70±1.22 |
| BgP | 4.17±2.94 | 7.99±6.56 | 1.57±0.71 |
| SUM | 46.78 | 67.83 | |

Indoor and outdoor concentrations of PAHs in TSP (ng/m3).

# Model description – calculation procedure

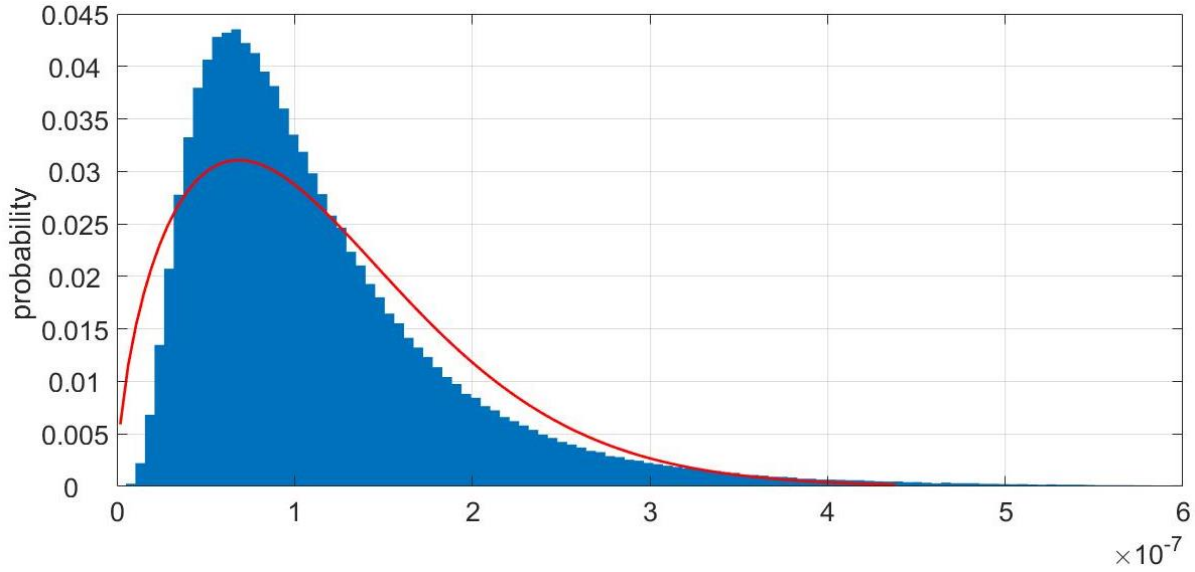


# Results – PAHs indoor, outdoor, and equivalent BaP-eq values

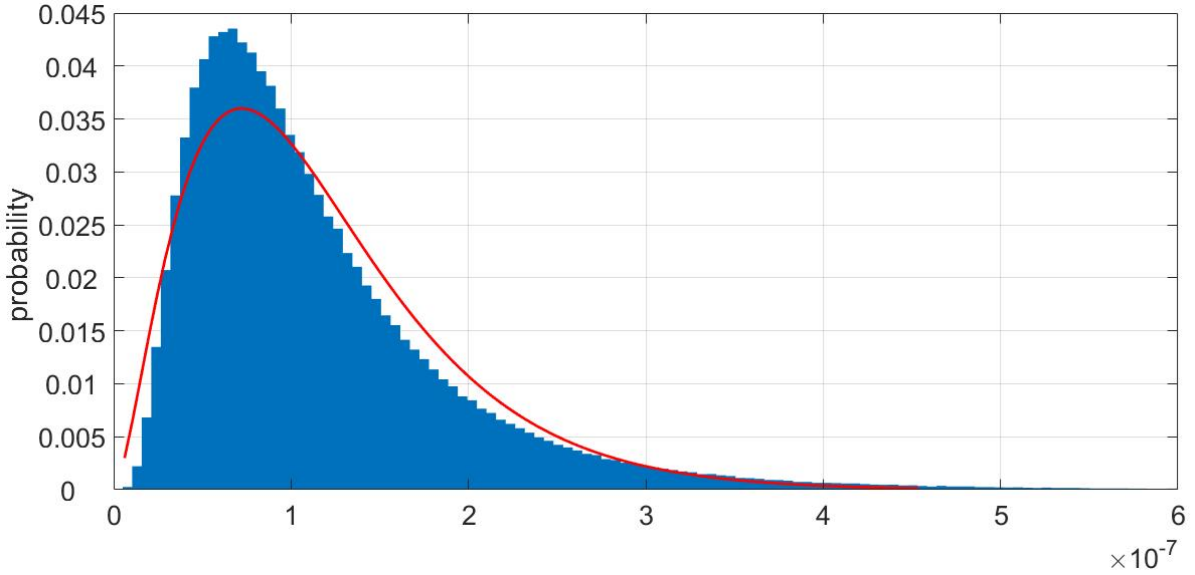
- The 2- and 3-ring PAHs were much lower than 5- and 6-ring PAHs;
- The 5- and 6-ring PAHs were the dominant compounds accounting for more of 90% of total PAHs;
- These, high molecular weight components, are mostly bound with particulate phase;
- These, high molecular weight PAHs usually come from combustion of solid fuels;
- I/O ratios are an indicator of the relative strengths of the indoor and outdoor sources;
- The BaP-eq concentration is almost two times higher in the indoor than in the outdoor environment.

| | | Outdoor | | Indoor | |
|---|---|---|---|---|---|
| PAHs | TEF | TSP | Stdev | TSP | Stdev |
| Nap | 0.001 | 0.0002 | 0.0003 | 0.0001 | 0.0001 |
| Ace | 0.001 | 0.0006 | 0.0012 | 0.0002 | 0.0001 |
| Ane | 0.001 | 0.0002 | 0.0001 | 0.0002 | 0.0001 |
| Flu | 0.001 | 0.0003 | 0.0004 | 0.0003 | 0.0001 |
| Phe | 0.001 | 0.0003 | 0.0002 | 0.0004 | 0.0002 |
| Ant | 0.01 | 0.0016 | 0.0013 | 0.0012 | 0.0007 |
| Fla | 0.001 | 0.0037 | 0.0044 | 0.0027 | 0.0024 |
| Pyr | 0.001 | 0.0041 | 0.0047 | 0.0033 | 0.0029 |
| BaA | 0.1 | 0.6825 | 0.6803 | 0.6946 | 0.7500 |
| Chy | 0.01 | 0.0824 | 0.0792 | 0.0832 | 0.0884 |
| BbF | 0.1 | 0.5980 | 0.4865 | 0.9097 | 0.8361 |
| BkF | 0.1 | 0.4663 | 0.3722 | 0.7710 | 0.7734 |
| BaP | 1 | 5.5983 | 4.8993 | 10.4781 | 9.5028 |
| InP | 0.1 | 0.4070 | 0.3031 | 0.7622 | 0.6366 |
| DbA | 1 | 1.4069 | 1.2072 | 2.4981 | 2.0429 |
| BgP | 0.01 | 0.0417 | 0.0294 | 0.0799 | 0.0656 |
| BaP-eq | | 9.2940 | 8.0699 | 16.2850 | 14.7024 |

# Results – children Incremental Life Cancer Risk (ILCR)




Children ILCR probability histogram fitted with Weibull distribution.




Children ILCR probability histogram fitted with Gamma distribution.

# Conclusions and future work

- The indoor PAH concentrations were higher than in the common European schools;
- This can be explained by poor ventilation, incomplete combustion in the boiler furnace, and poor condition of windows which allow PAHs penetration from outdoor environment;
- Mean value of calculated ILCR distributions is $1.2\ 10^{-7}$ which is considered acceptable according to accepted standards;
- However, as ILCR of $1\ 10^{-6}$ is considered as minimum value for acceptable risk it is clear that efforts should be made to lower the current calculated ILCR values;
- The I/O ratios pointed out strong influence of indoor emission sources, especially for high molecular weight PAHs;
- Although the average estimated lifetime lung cancer risk for this study was lower than the WHO and EPA recommended values, It is necessary to point out that the risk assessment was conducted using PAH concentrations only from TSP;
- Thus, it is expected that PAH concentrations in both gas and particle phases will be measured and taken into account in the model in the future work;
- It is also important to note that relatively low ILCR predicted values are caused only by PAHs which children inhaled during school time, and not during all 24 h, and thus should be taken carefully as an important factor for consideration for improving school heating and ventilation systems.

# THANK YOU FOR YOUR ATTENTION

**Acknowledgments**

The authors would like to acknowledge high appreciation for the support and promotion of this work to the: Public Enterprise ”Electric power industry of Serbia”, Belgrade, Serbia, and Ministry of Education and Science of Republic of Serbia (Project No. III42010, TR33050, and III42008)