Clean Air 40 YEARS

POLYCYCLIC AROMATIC HYDROCARBONS: POPULATION EXPOSURE

Brief overview

Workplan element 1.1.3.1. *Analysis of the effectiveness of the implementation of the Protocol on POPs*

MSC-E in support of TFTEI . *Contribution to evaluation of stricter measures for mitigation of B(a)P pollution levels; analysis of trends, key sources and projections*

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are organic substances that persist in the environment, accumulate in living organisms and pose a risk to human health and the environment. In addition, degradation of PAHs may result in formation of other groups of toxic pollutants such as nitrated PAHs (**nitro-PAHs)** and oxygenated PAHs (**oxy-PAHs**). PAHs are considered as harmful substances due to their carcinogenic potency as well as cardiovascular effects for human health. The main routes of exposure to PAH for the general population are inhalation and ingestion [*EFSA*, 2008][1]. Contamination of food by PAHs may be due to presence of these substances in air, water and soil. Some studies suppose that dermal contact also might have significant impact that is comparable with inhalation exposure [*Strandberg et al.*, 2018].

The Long-term strategy of the Convention on Long-Range Transboundary Air Pollution (Convention) highlights importance of continued scientific research that can support additional efforts for the reduction of unintentional releases of PAHs in the EMEP region. Protocol on POPs to the Convention includes 4PAHs (B(a)P, B(b)F, B(k)F, and IP).

Sources, levels and trends

PAHs can be released to the atmosphere during incomplete combustion of fossil fuels and biomass burning. According to officially submitted emission inventories, in the majority of EMEP countries the largest contribution to PAH emissions is made by the Residential combustion sector (Fig.1). At

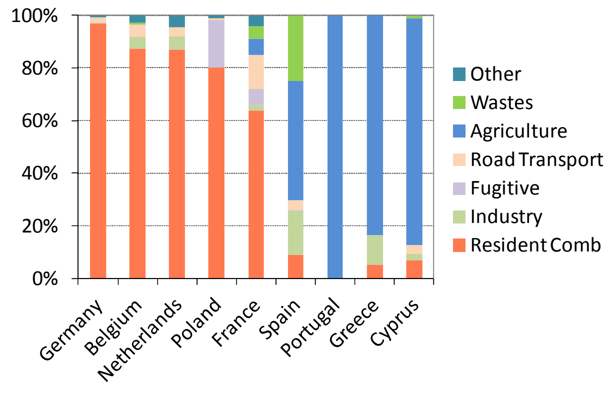

Fig.1. *Sector distribution of PAH emissions officially reported by some of the EMEP countries for 2016*

[1] The list of references are available on MSC-E website: http://en.msceast.org/reports/booklet_2019.pdf

the same time inventories of in Southern Europe, such as Spain, Portugal, Greece, and Cyprus are characterized by prevailing contribution of PAH emissions from burning of agricultural residues and wastes. Thematic session on B(a)P during the 2nd joint session of the Working Group on Effects and the Steering Body to EMEP paid specific attention to the importance of PAH emissions from residential combustion and biomass burning. It was emphasized that evaluation of emissions from these source categories is currently subject of substantial uncertainties.

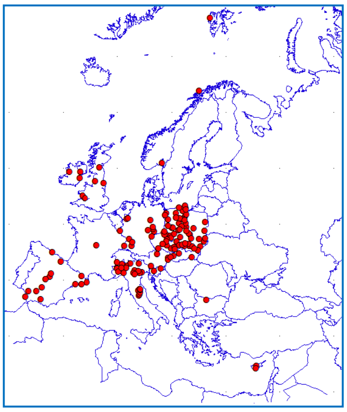

__Fig. 2.__ Locations of AIRBASE monitoring sites, reported increasing trends of annual mean B(a)P air concentrations in period

B(a)P is the best studied compound among the PAHs and is often used as a marker in risk assessment studies. Analysis of B(a)P concentrations, measured by national monitoring sites in the period 2007-2017, indicates both decreasing and increasing trends in pollution levels in the EMEP countries. In particular, about 65% of sites reported decreasing B(a)P concentrations during this period. At the same time, significant amount of sites indicates increasing concentrations, which can be noted for Poland, Czech Republic, and Italy, as well as for the UK, Ireland, Spain, Austria, Slovakia, and Cyprus (Fig.2).

Time-series of observed B(a)P air concentrations in the EMEP countries can be compared with temporal variations of national emission data (Fig.3). It can be seen that this period is generally characterized by almost stable levels of both observed B(a)P concentrations and emissions.

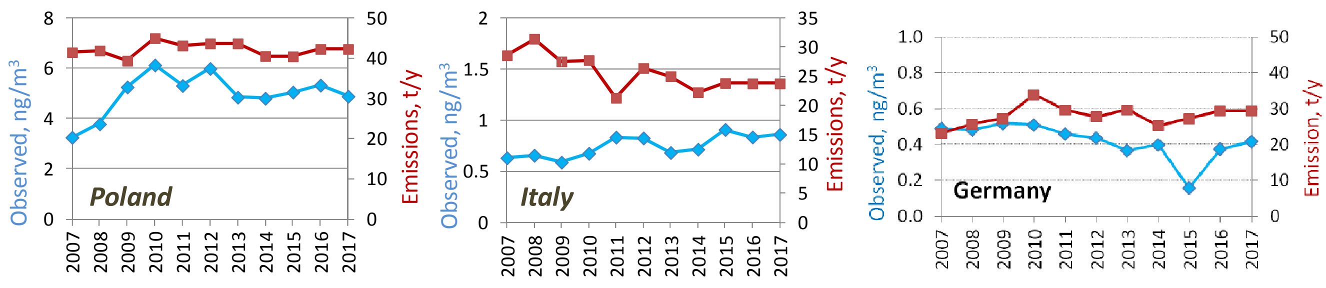

__Fig. 3.__ Temporal variations of averaged B(a)P annual mean air concentrations in the selected EMEP countries in period 2007-2017 in comparison with variations of annual emissions

Exceedances of B(a)P air quality guidelines

Available AIRBASE monitoring data and model assessment of B(a)P air concentrations indicate exceedances of EU and WHO air quality guidelines in the EMEP region, especially in countries of Central and Eastern Europe. According to the modelling results (Fig.4), about 10% of total population of the EMEP countries in 2017 lived in areas with exceeded EU target level (1.0 ng/m^3) for annual mean B(a)P air concentrations. The upper assessment thresholds (UAT) - 0.6 ng/m^3 and lower assessment thresholds (LAT)[2] - 0.4 ng/m^3 values were exceeded in the areas with 20% and 35% of population, respectively (Fig. 5). It can be seen that most of these exceedances took place for the population of urban areas.

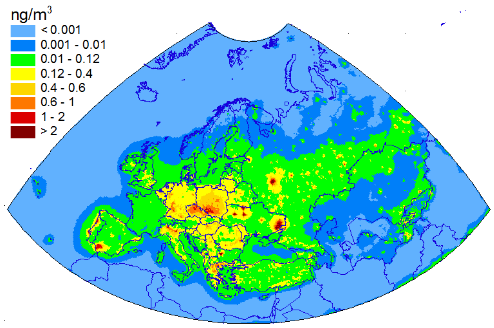

Fig. 4. *Spatial distribution of B(a)P in 2017, ng/m^3*

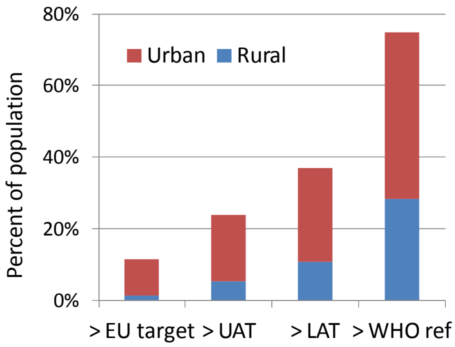

Fig. 5. *Percentage of urban and rural population of the EMEP countries lived in areas with annual mean B(a)P air concentrations in 2017 above the EU limit values, and WHO reference level*

In case of the WHO reference level for B(a)P, equal to 0.12 ng/m^3, about 70% of population in the EMEP countries living in areas with annual mean air concentrations above the WHO reference level.

Population exposure to mixture of toxic PAHs

Evaluation of population exposure to elevated B(a)P air concentrations can be extended by the analysis of the toxicity of PM chemical composition and evaluation of cumulative human health risk [*Liu et al.*, 2019]. Along with B(a)P, atmospheric aerosol particles can be enriched by mixture of various toxic PAH compounds.

Toxicity of PAHs can be related to that of B(a)P using the toxicity equivalency factors (TEFs) for individual PAHs. These TEFs can be applied to characterize the carcinogenic potency of each considered PAH and calculate B(a)P equivalent concentrations of PAH

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2 Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 mixture for risk assessment. For PAH derivatives (nitro-PAH, oxy-PAH) TEFs also could be generated to estimate impact of these groups of contaminants [*Wei et al*., 2015].

At present there exist a number of sets of TEFs for PAHs such as those developed under WHO [*ALS*, 2013], US EPA [*EPA*, 2010] and others. These sets can differ from one another by the considered PAHs and by the values of TEFs defined for individual PAHs. Inclusion of wider list of PAHs into analysis of population exposure could allow more accurate estimation of carcinogenic potency of PAH mixtures [*Samburova et al*., 2017]. In particular, the study indicated that total PAH toxicity of 4 PAHs, currently included to the Protocol on POPs, can be lower than the toxicity of 16 PAHs up to a factor of 2-3.

Air pollution by B(a)P and other toxic PAHs in the EMEP region is recognized as a significant problem for human health and ecosystems by a number of organizations and conventions including EEA, HELCOM, OSPAR, and some other. In particular, according to the analysis of EEA [*EEA*, 2018], about 20 % of the urban population in the EU countries was exposed to B(a)P annual concentrations above the EU target value, and the extent of the urban population exposed to high B(a)P concentrations did not change significantly since 2008.

Along with B(a)P the Ambient Air Quality Directive [*EU*, 2004] considers monitoring of concentrations of additional 6 PAHs (Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(j)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, and Dibenz(a,h)anthracene). Activities of European Chemicals Agency (ECHA) regarding PAH content in various products take into consideration 8 PAHs (Benzo[a]pyrene, Benzo[e]pyrene, Benzo[a]anthracene, Dibenzo[a,h]anthracene, Benzo[b]fluoranthene, Benzo[j]fluoranthene, Benzo[k]fluoranthene, Chrysene). Besides, according to the new POP Regulation of EU (2019/1021), ECHA is going to strengthen co-operation with LRTAP Convention, Stockholm Convention regarding identification of new POPs.

Thus, further analysis and evaluation of population exposure to toxic PAHs and their adverse effects on human health requires co-operation of the EMEP Centres, Working Group on Effects, TFH, TFTEI, and with EEA and ECHA. Joint efforts can be important for the analysis of the effectiveness of POP Protocol with regard to PAHs in order to improve measures on reduction of PAH pollution.

More detailed information on PAHs is available on the MSC-E website: www.msceast.org

This booklet has been prepared by the EMEP/Meteorological Synthesizing Centre – East (MSC-E)

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