

## A three-year analysis of toxic benzene levels and associated impact in Ploiesti City, Romania

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**Table S1.** Main parameters used to define the scenarios for ADD and LADD calculations in ExpoFIRST and corresponding equations.

Variable	Selection/Input
Route of exposure	Inhalation
Exposure descriptor	central tendency
medium type	air
Location, activity category, or product category	Total outdoors
Gender	Male and Female
Manage contaminants	Molecular weight (78.11184 g/mol); Dermal permeability coefficient (0.14 cm/h)
Exposure Frequency (EF)	100 days (ADD); 365 days (LADD)
Exposure Time (ET)	Scenario 1 and 2 (default); Scenario 3 (180 minutes for all age bins)
ADD	$ADD = (C \times InhR \times ET \times EF \times ED) / (1440 \text{ (min/day)} \times AT \times BW)$ where: ADD - Average Daily Dose (mg/kg-day) C - Concentration of contaminant in air (mg/m <sup>3</sup> ) EF - Exposure Frequency (days/year) ED - Exposure Duration (years) AT - Averaging Time (days) InhR - Inhalation Rate (m <sup>3</sup> /day) ET - Exposure Time (min/day) BW - Body Weight (kg).
LADD	$LADD = (C \times 1day \times InhR \times ET \times EF \times ED) / (24 \text{ hours} \times [BW] \times AT)$ where: LADD - Lifetime average daily dose (mg/kg-day) C - Concentration of contaminant in air (mg/m <sup>3</sup> ) InhR - Inhalation rate (m <sup>3</sup> /kg-day) ET - Exposure time (hours/day) EF - Exposure frequency (days/year) ED - Exposure duration (years) AT - Average time (days) <i>For cancer effects, equals 70 years * 365 days/year</i> [BW] - Body weight (kg) will be included in the denominator, if InhR is not normalized to body weight.

**EPA's Exposure Factors Interactive Resource for Scenarios Tool**

Current Scenario: [Media & Receptors](#) [Contaminant](#) [Exposure Factors](#) [Results](#) [Go To Scenario](#)

Scenario Name: LADD

Route of Exposure: Inhalation Dose Metric: LADD Exposure Descriptor: Central Tendency

General Model:

$$LADD = \frac{C_{air} \times 1day \times InhR \times ET \times EF \times ED}{24 \text{ hours} \times [BW] \times AT}$$

LADD = Lifetime average daily dose (mg/kg-day)  
 C<sub>air</sub> = Concentration of contaminant in air (mg/m<sup>3</sup>)  
 InhR = Inhalation rate (m<sup>3</sup>/kg-day)  
 ET = Exposure time (hours/day)  
 EF = Exposure frequency (days/year)  
 ED = Exposure duration (years)  
 AT = Averaging time (days)  
 For cancer effects, equals 70 years \* 365 days/year

[BW] = Body weight (kg) will be included in the denominator if InhR is not normalized to body weight.

**Note:** Equation shown here is the general equation. The units in final equation shown on the results tab may differ depending on user selections (e.g., inhalation rate may be in units of m<sup>3</sup>/day, m<sup>3</sup>/min, or m<sup>3</sup>/kg).

Parameter Selections:

	Central Tendency	Upper Percentile
Inhalation Rate (InhR)	<input checked="" type="radio"/>	<input type="radio"/>
Contaminant Concentration (C)	<input checked="" type="radio"/>	<input type="radio"/>
Exposure Time (ET)	<input checked="" type="radio"/>	<input type="radio"/>
Exposure Frequency (EF)	<input checked="" type="radio"/>	<input type="radio"/>
Event Frequency (EV)	<input checked="" type="radio"/>	<input type="radio"/>

Exposure duration (ED) and averaging time (AT) are auto-calculated and are based on continuous exposure. EV and ET may not apply in all scenarios. The mean will be used for body weight (BW) to normalize unadjusted inhR.

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**EPA's Exposure Factors Interactive Resource for Scenarios Tool**

Current Scenario: [Inhalation\(LADD\)](#) [Central Tendency](#) [Media & Receptors](#) [Contaminant](#) [Exposure Factors](#) [Results](#) [Go To Scenario](#)

Route of Exposure: Inhalation Scenario Type: LADD Exposure Descriptor: Central Tendency

Media Type: Air Inhalation Rate Type: Long-Term (daily rate)

Location, Activity, or Product: Total Outdoors Location, Activity, or Product Subgroup: All [Search Categories](#)

Gender: Male and Female Intensity:

Define Receptors of Interest: [define age bins](#) [delete all age bins](#) [define groups](#) [delete all groups](#)

User-Defined Age Bins: [define age bins](#) [delete all age bins](#)

Other Population Groups: [define groups](#) [delete all groups](#)

Group Type: User-Defined Age Bin Group Name: Birth to < 70 years

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**Exposure Calculator**

**EPA's Exposure Factors Interactive Resource for Scenarios Tool**

Current Scenario: [Inhalation\(LADD\)](#) [Central Tendency](#) [Air](#) [Total Outdoors](#) [All](#) [Male and Female](#) [Long-Term \(daily rate\)](#) [benzene](#) [0.035](#) [mg/m3](#) [central tendency](#) [Data Source:](#) [Manage Contaminants](#) [Go To Scenario](#)

**Important Note:** **ExposureCalculator** does not contain contaminant-specific data. Users must supply their data, which can then be saved and managed in their local version of the tool.

Contaminant Evaluated: benzene

Contaminant Concentration (C): 0.035 Units: mg/m<sup>3</sup> central tendency

Data Source\*: [Manage Contaminants](#) \*not a required field

**Manage Chemicals**

Contaminant Name	MW	Kp
benzene	78.1184	0.34

MW = molecular weight (g/mol)  
 Kp = dermal permeability coefficient (cm/hour)

[Save & Close](#)

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**Exposure Calculator**

**EPA's Exposure Factors Interactive Resource for Scenarios Tool**

Current Scenario: [Inhalation\(LADD\)](#) [Central Tendency](#) [Air](#) [Total Outdoors](#) [All](#) [Male and Female](#) [Long-Term \(daily rate\)](#) [benzene](#) [0.035](#) [mg/m3](#) [Go To Scenario](#)

Scenario Description: [Media & Receptors](#) [Contaminant](#) [Exposure Factors](#) [Results](#)

Algorithm:  $LADD = \frac{C_{air}(mg/m^3) \times InhR(m^3/day) \times ET(min/day) \times EF(days/year) \times ED(years)}{1440(min/day) \times AT(days) \times BW(kg)}$

Select Exposure Group: [Age Bin: Birth to < 70 years](#)

Parameter Name	Value	Units	Description*
inhalation rate	15	m <sup>3</sup> /day	EPA Table 9-1 MB&F; Mean; Original Data Source: Aroos-Arth and Blandford, 2007
exposure time	180	min/day	User-defined; Mean
exposure frequency	365	days/year	User-defined; Mean
exposure duration	30	years	User-defined
averaging time	25550	days	70 years * 365 days
body weight	70	kg	EPA Table 9-3 MB&F; Mean; Original Data Source: U.S. EPA Analysis of NHANES 1999-2006 data

[Bulk Modify Factors](#)

[Quick Reference Tables](#)

\* Quick reference tables contain data that are not programmed into ExposureCalculator, but that may be useful for estimating certain exposure factors.

\* To expand, click the symbol

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**EPA's Exposure Factors Interactive Resource for Scenarios Tool**

Current Scenario: [Inhalation\(LADD\)](#) [Central Tendency](#) [Air](#) [Total Outdoors](#) [All](#) [Male and Female](#) [Long-Term \(daily rate\)](#) [benzene](#) [0.035](#) [mg/m3](#) [Go To Scenario](#)

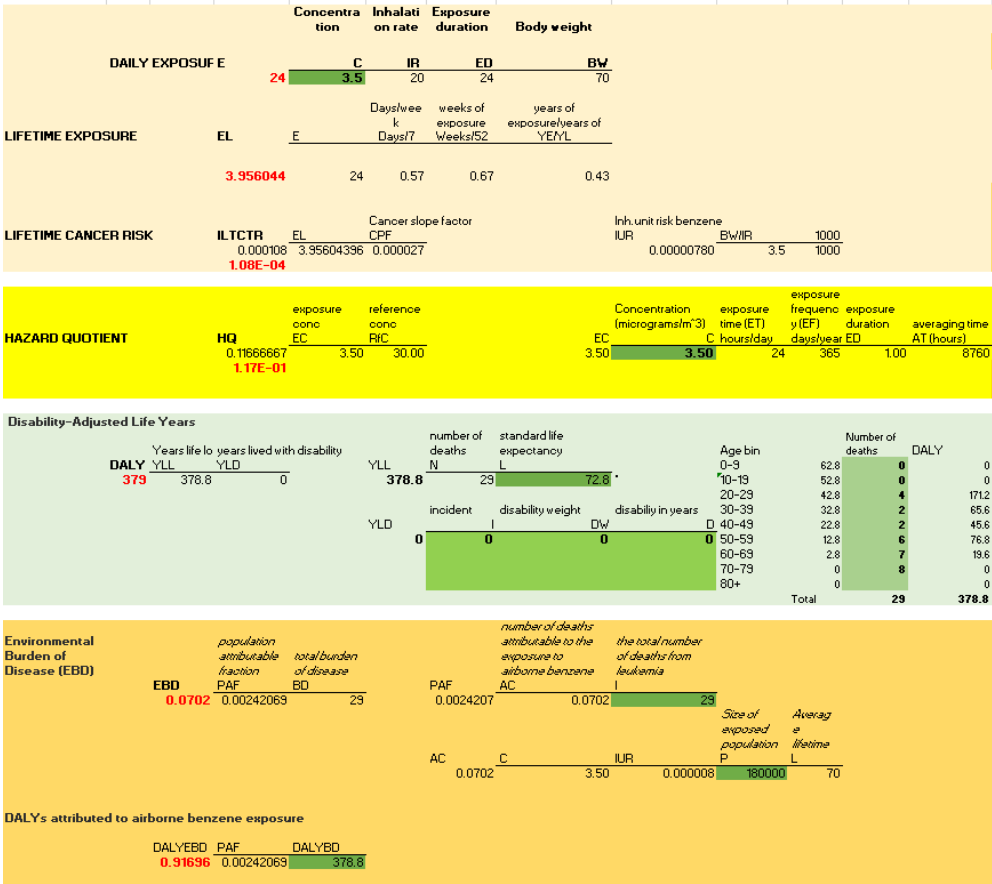
Scenario Description: [Media & Receptors](#) [Contaminant](#) [Exposure Factors](#) [Results](#)

Algorithm:  $LADD = \frac{C_{air}(mg/m^3) \times InhR(m^3/day) \times ET(min/day) \times EF(days/year) \times ED(years)}{1440(min/day) \times AT(days) \times BW(kg)}$

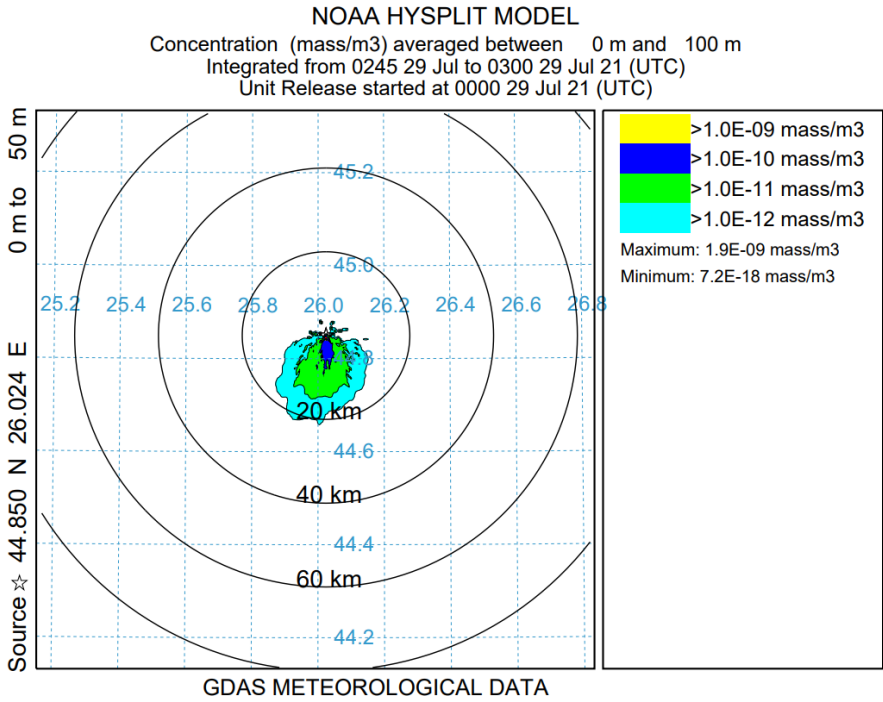
Results:

Exposure Group	Data Type	Result	Units
Birth to < 70 years	LADD	3.95E-04	mg/kg-day

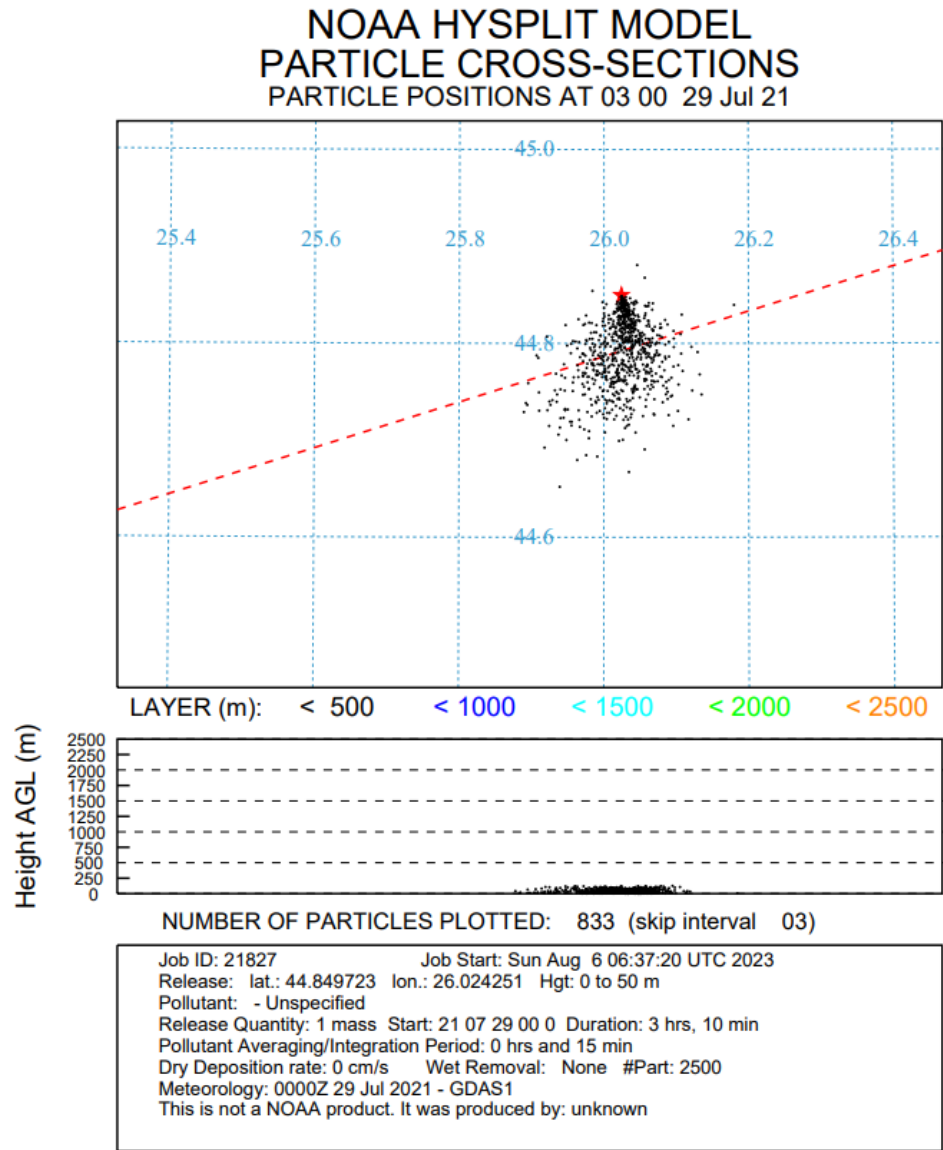
Figure S1. Example of the LADD computation in ExpoFIRST (screen captures)



**Figure S2.** Screen capture with an example of parameters calculation (green cells are for inputs and red text highlights the values computed by the algorithms) – See Supplementary File 2 (excel file).



**Figure S3.** Dispersion modeling for the maximum concentration of benzene recorded in Ploiesti area using the HYSPLIT model



**Figure S4.** Modeling of the particle positions using HYSPLIT Model

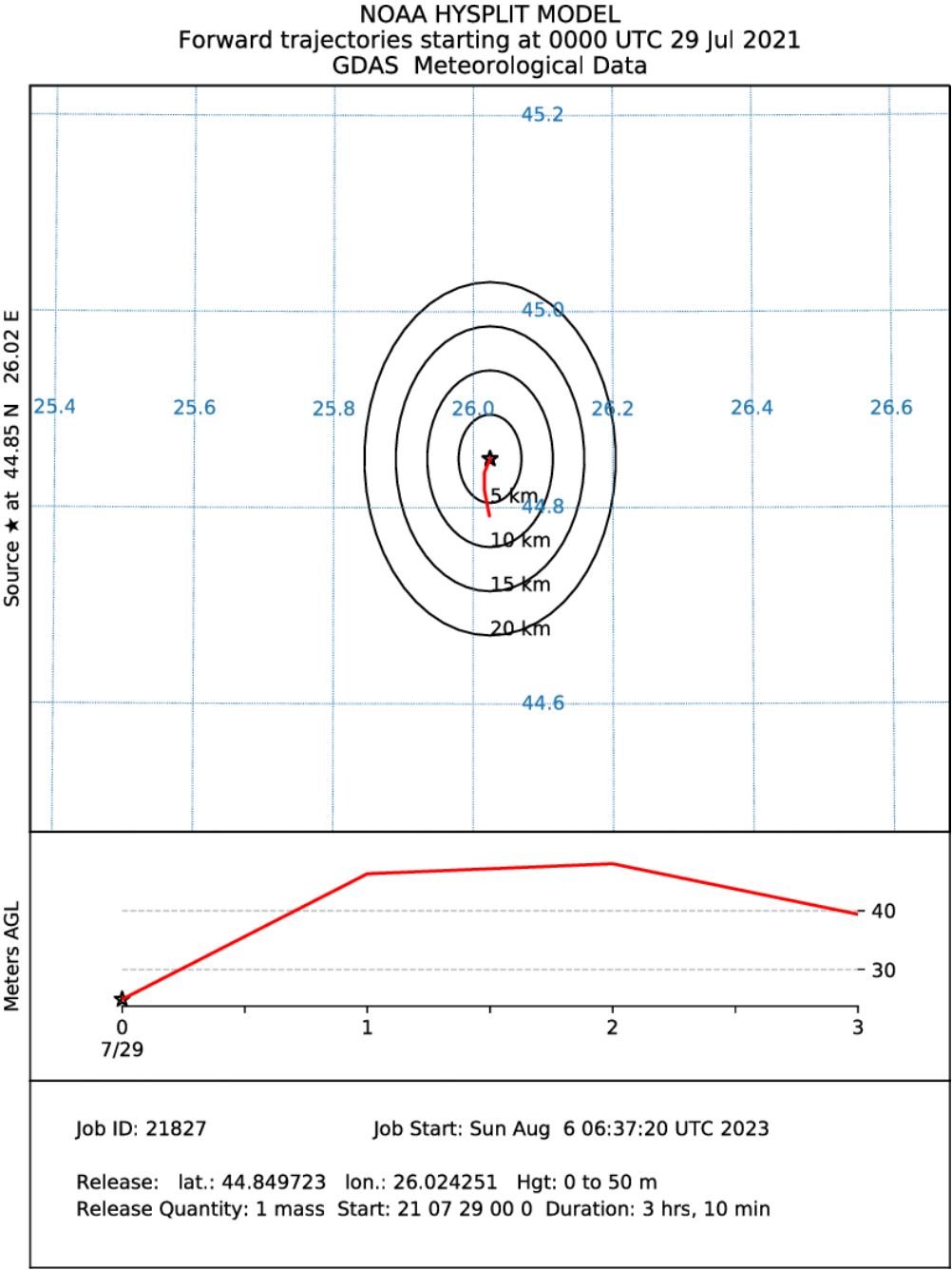


Figure S5. Forward trajectories provided by the HYSPLIT model

**Table S2.** Annual concentrations of benzene ( $\mu\text{g}/\text{m}^3$ ) retrieved from literature and results from the current study.

City	Country	Type of Site	Benzene ( $\mu\text{g}/\text{m}^3$ )	Source
Berlin	Germany	Urban region	2.09	Monod et al, 2001 [29]
Bucharest	Romania	Urban region	1.75	
Krakow	Poland	Urban region	2.43	
London	U.K.	Urban region	0.8	
Prague	Czech Republic	Urban region	2.46	
Rome	Italy	Urban region	3.62	
Vienna	Austria	Urban region	0.99	
Warsaw	Poland	Urban region	0.75	
Paris	France	Urban region	1.42	
Hong Kong	Special Region of China	Urban region	1.64	Jia et al., 2016 [30]
Lanzhou,	China	Urban region	1.94	
Wuhan		Urban region	1.7	
Guangzhou		Urban region	2.4	
Shanghai		Industrial (petrochemical area)	6.41	
Changzhi		Industrial	1.40	Zhang et al., 2022 [34]
Houston	USA	Urban region	0.34	Jobson et al., 2004 [35]
Naples Metropolitan area	Italy	Industrial	9	Iovino et al., 2009 [36]
Milan		Industrial	1.9 (Before lockdown) 0.96 (During lockdown)	Collivignarelli et al., 2020 [37]
Agii Theodore Corinthia		Industrial (oil refinery)	0.8	Kalabokas et al., 2001 [38]
Athens (Patisision)	Greece	Urban (heavy traffic)	5.63	Begou and Kassomenos (2020) [9]
Piraeus		Harbor area	2.81	
Nea Smirni		Urban	1.68	
Elefsina		Urban-Industrial	0.81	
Thessaloniki (Agia Sofia)		Urban	3	
Kordelio		Urban-Industrial	2.14	
Sindos		Urban-Industrial	0.96	
Ulsan (industrial area)	Koreea	Industrial	2.1	Na et al., 2001 [39]

Port Moody	Canada	Industrial (petrochemical area)	0.6	Ying et al.,2020 [40]
Kaohsiung	Taiwan	Industrial (petrochemical area)	1.32-2.31 at Site A 1.65-3.30 at Site B	Hsu et al., 2022 [41]
Delhi	India	Industrial	6.08 (Before lockdown) 0.38 (During lockdown)	Pakkattil et al., 2021 [42]
Mumbai		Industrial	1.65 (Before lockdown) 0.47 (During lockdown)	
Bengaluru		Industrial	0.99 (Before lockdown) 0.332 (During lockdown)	
Shah Alam	Malaysia	Industrial	1.11+/- 0.870 (Before lockdown) 0.640+/- 0.350 (During lockdown)	Latif et al., 2019 [43]
Cheras		Industrial	1.05+/- 0.830 (Before lockdown) 0.640+/- 0.370 (During lockdown)	
Ploiești	Romania	Urban, Industrial petrochemical area	3.25	Bodor et al., 2022 [18]
			3.5	(this study)
			2.7 (During lockdown)	