



**AKADEMIA GÓRNICZO-HUTNICZA  
IM. STANISŁAWA STASZICA W KRAKOWIE**

**AGH UNIVERSITY OF SCIENCE  
AND TECHNOLOGY**

**AGH**

# **Occurrence of PAHs and new tracer of polyethylene plastic combustion, 1,3,5-triphenylbenzene in PM10 collected in residential area of Krakow agglomeration, South Poland**

**Przemysław Furman<sup>1</sup>,**

**Katarzyna Styszko<sup>2</sup>, Alicja Skiba<sup>1</sup>, Magdalena Kistler<sup>3</sup>, Anne Kasper-Giebl<sup>3</sup>, Damian Zięba<sup>1,4</sup>**

<sup>1</sup> AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Department of Applied Nuclear Physics,

<sup>2</sup> AGH University, Faculty of Energy and Fuels, Department of Coal Chemistry and Environmental Sciences, Krakow, Poland

<sup>3</sup> TU Wien, Institute of Chemical Technologies and Analytics, Vienna, Austria

<sup>4</sup> Krakow Smog Alert, Krakow, Poland

# The problem of pollution in the Krakow agglomeration

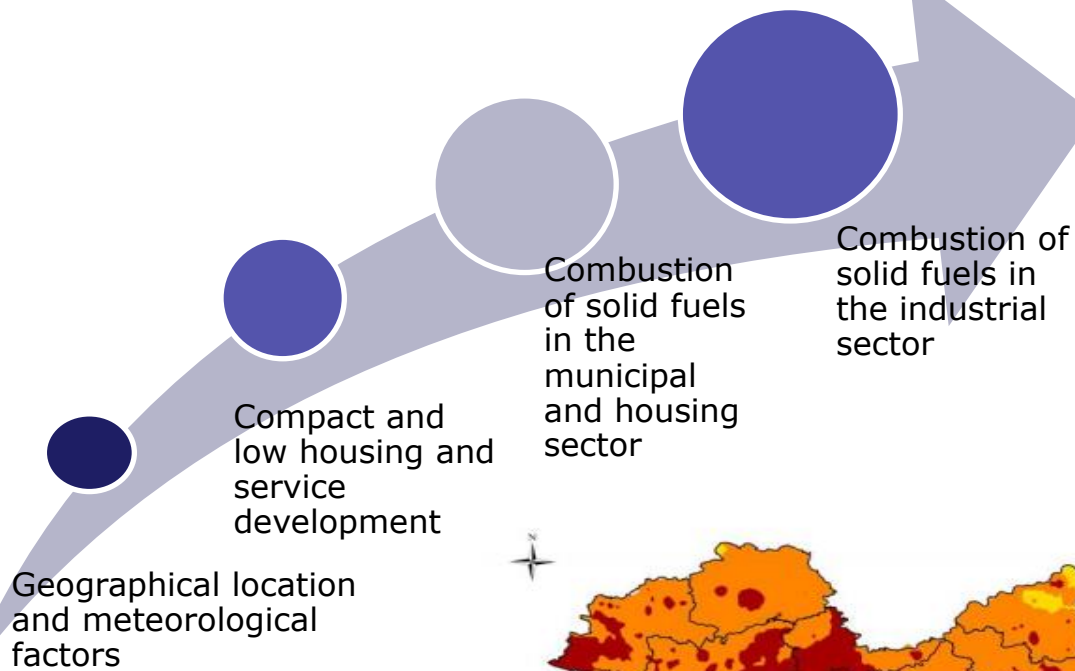


Fig. 1. Smog in Krakow

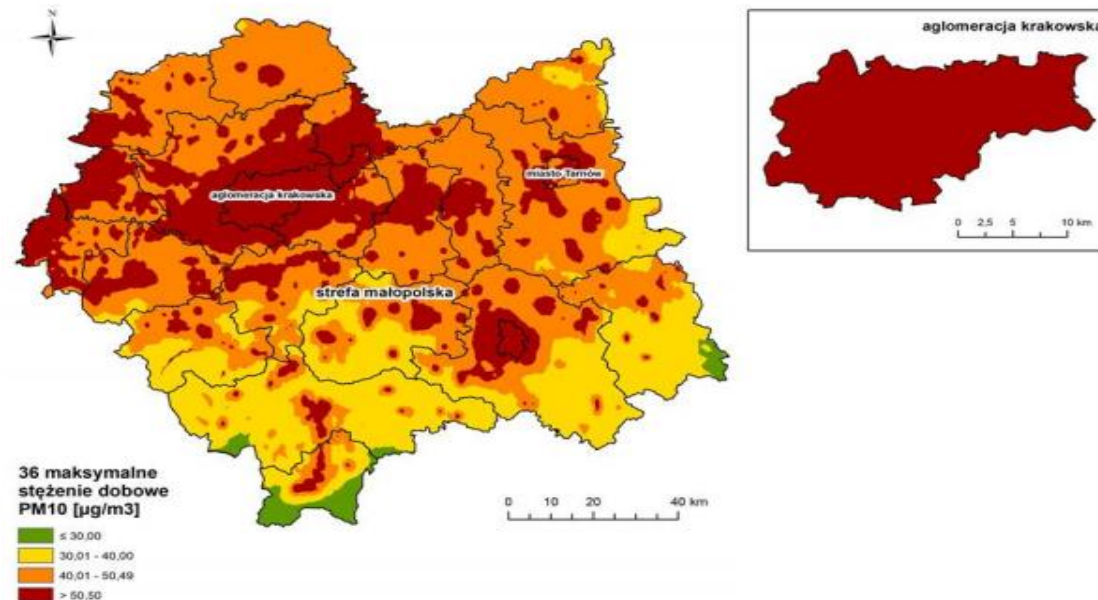


Fig. 2. PM10 map - Malopolska, Poland

# EXPERIMENTAL PART



## Place of sampling

**Total area:** 12,98km<sup>2</sup>

**Highest elevation:** 318m

**Lowest elevation:** 250m

**Population:**

- total: 19 149
- density: ~1 808/km<sup>2</sup>

According to a report by the World Health Organization (WHO), in 2016 Wadowice was classified as the twentieth most polluted city in the European Union.



*Fig. 3. Wadowice, Poland*



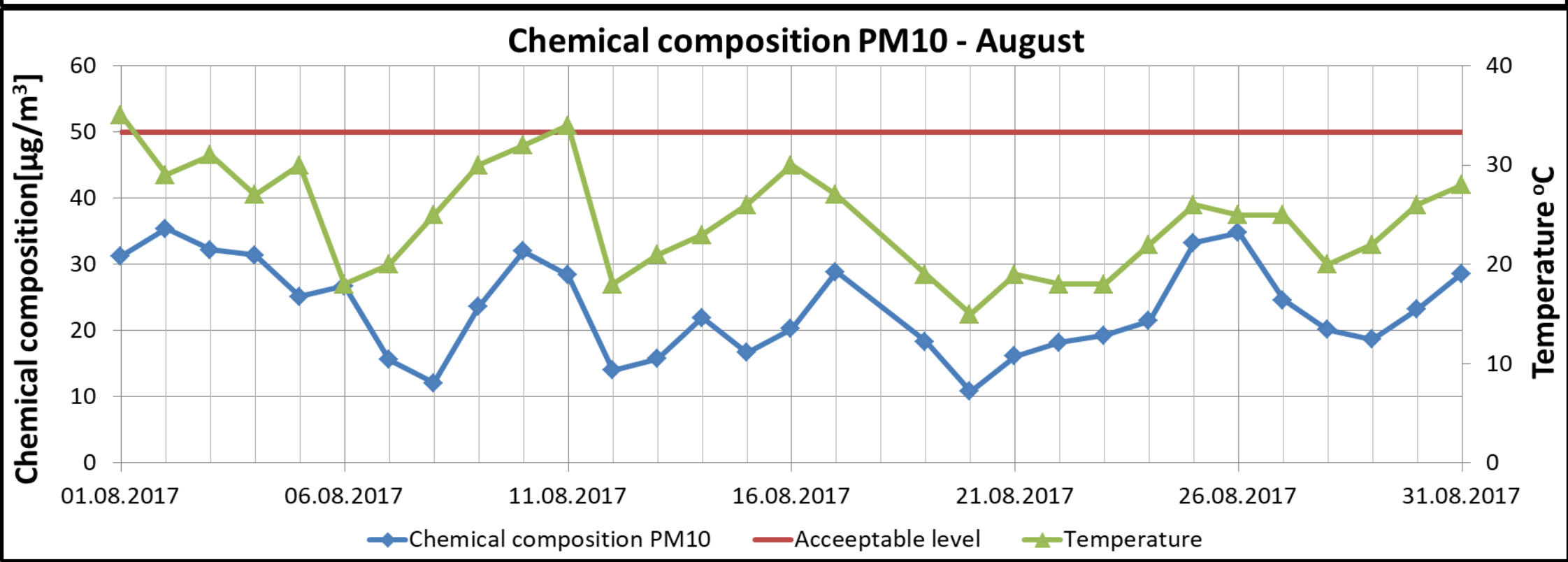
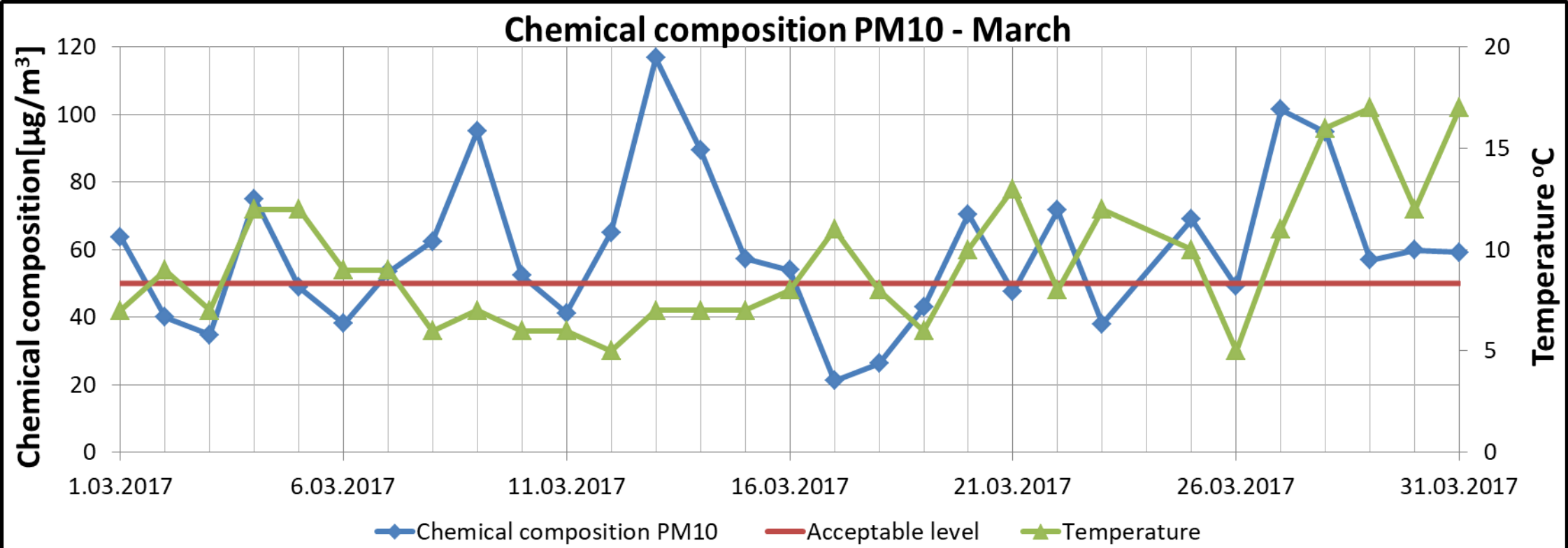
Fig. 4. Low-volume sampler PNS-15





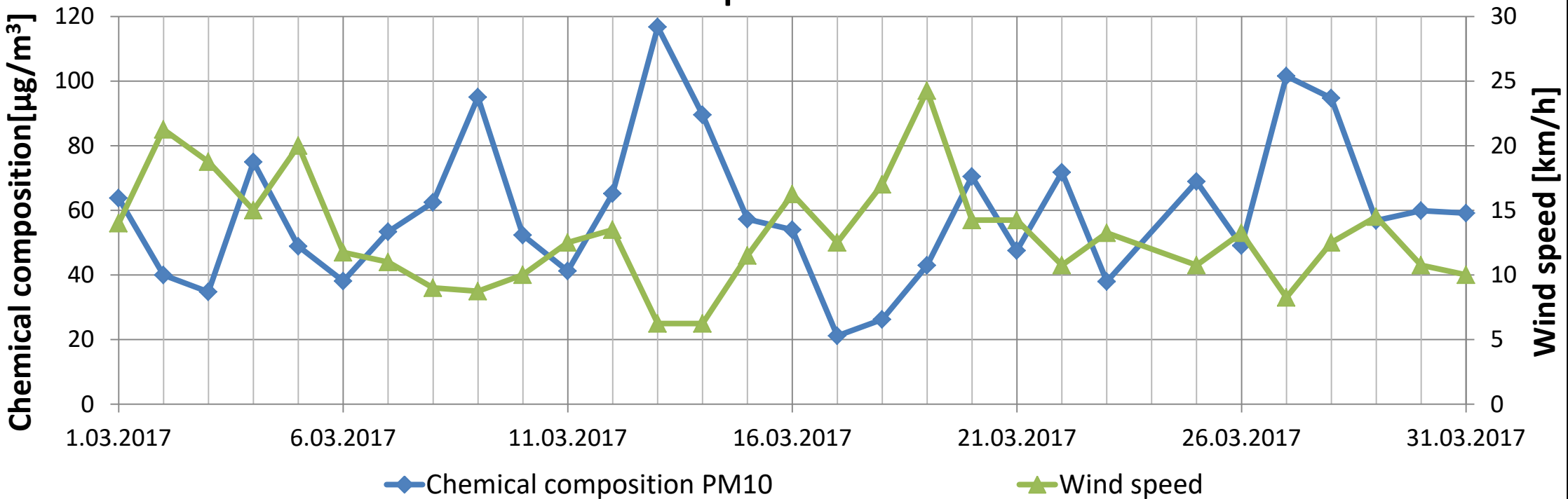
*Fig. 5. Gas chromatography mass spectrometry*

# Concentration of PM10

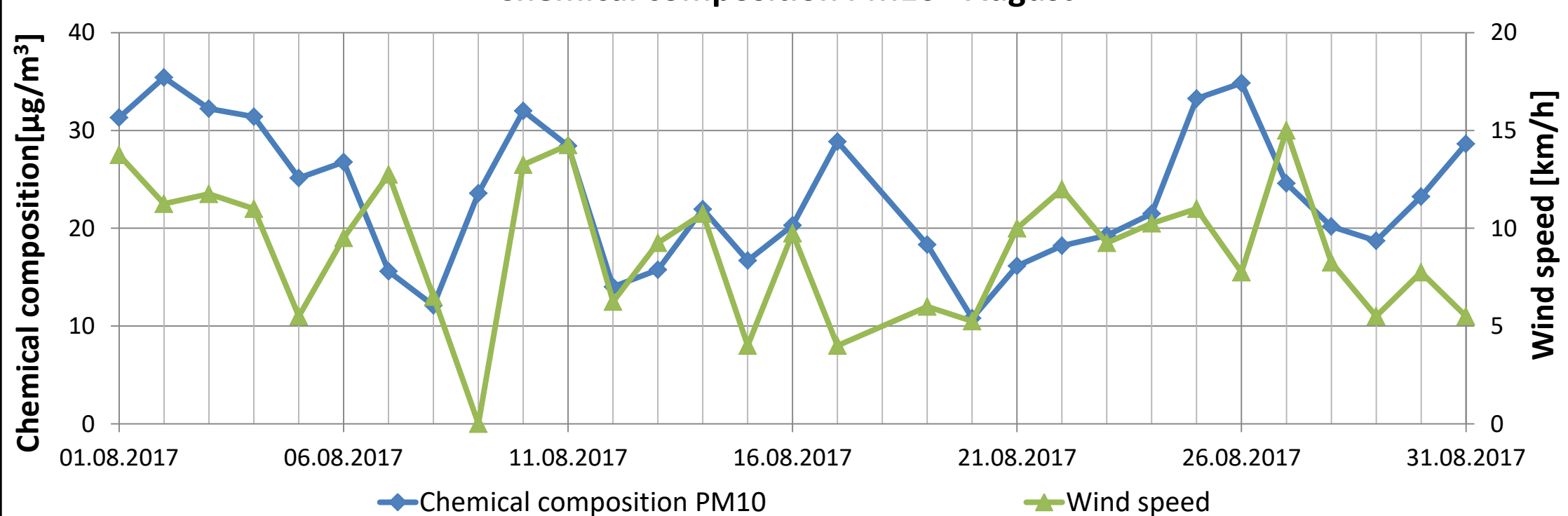




### Chemical composition PM10 - March

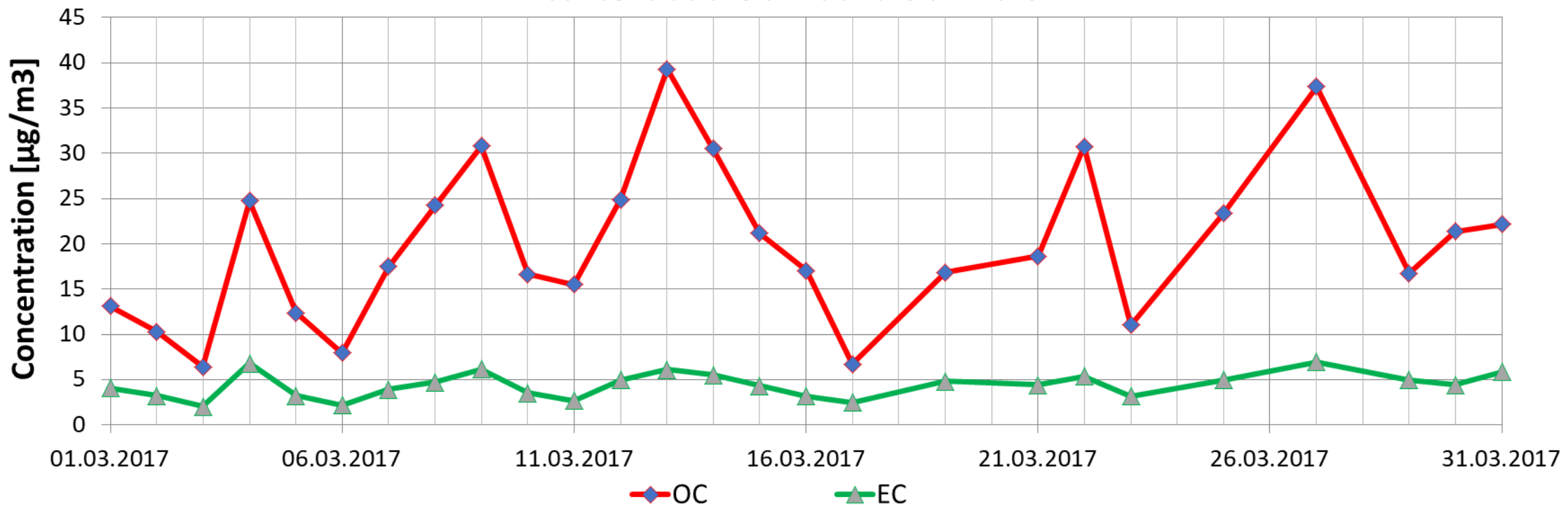


### Chemical composition PM10 - August

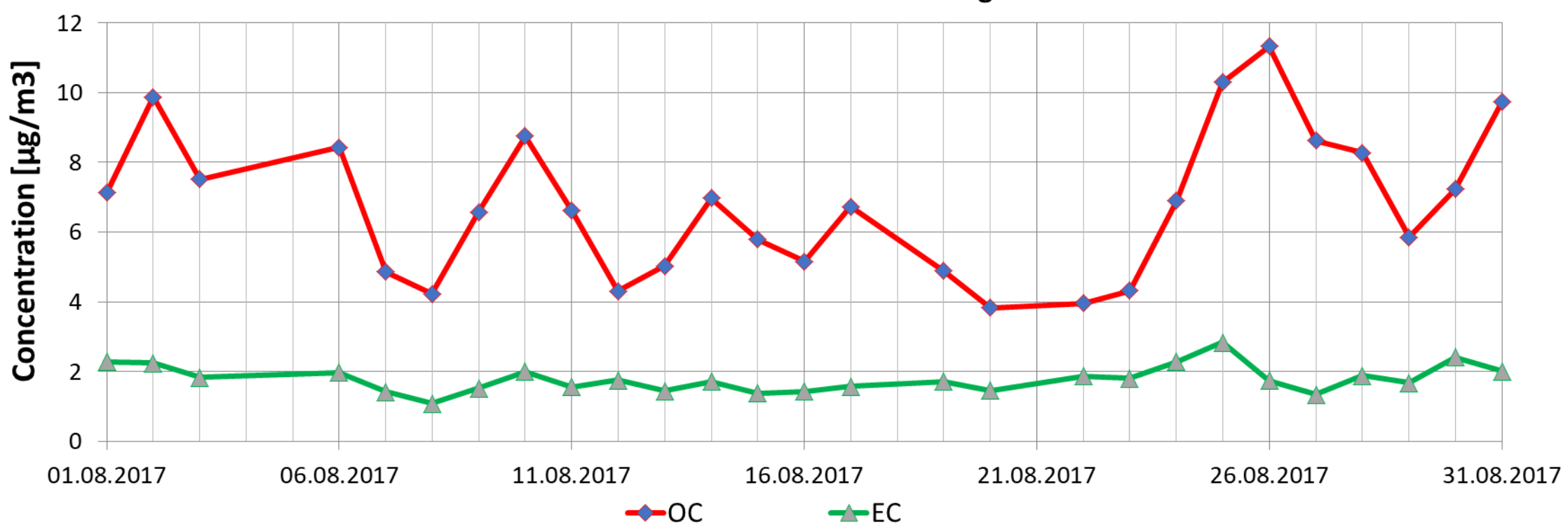


# Concentrations of organic carbon (OC) and elementar carbon (EC)

### Concentrations of EC and OC - March



### Concentrations of EC and OC - August



# Concentrations of PAHs



# Percentages of individual PAHs

Chemical compound	March 2017		August 2017	
	Average concentrations of compounds ng/m <sup>3</sup>	Percentage in the PAH mixture, %	Average concentrations of compounds ng/m <sup>3</sup>	Percentage in the PAH mixture, %
Acenaphthylene	0,45	0,53	-	-
Fluorene	0,62	0,74	-	-
Phenanthrene	2,34	2,78	0,45	4,24
Pyrene	8,17	9,71	0,75	7,06
Benzo(a)anthracene	11,91	14,15	1,20	11,30
Chrysene	10,37	12,32	1,04	9,79
Benzo(b)fluoranthene	11,14	13,25	1,62	15,25
Benzo(k)fluoranthene	5,60	6,66	0,81	7,64
Benzo(a)pyrene	11,09	13,18	1,45	13,65
Indene(1,2,3-cd)pyrene	8,53	10,14	1,44	13,56
Dibenzo(a, h)anthracene	11,46	13,62	1,86	17,51
Benzo(g,h,i)perylene	2,46	2,92	-	-
<b>Total:</b>	<b>84,14</b>	<b>100</b>	<b>10,62</b>	<b>100</b>

# Exposure indicators of PAHs

Place		MEQ ng/m <sup>3</sup>	CEQ ng/m <sup>3</sup>	TEQ ng/m <sup>3</sup>
Wadowice Poland	March 2017	22,08	72,23	0,094
	August 2017	3,05	11,27	0,014
Delhi India	Winter 2007	20,07	59,75	0,106
	Summer 2007/2008	7,87	23,09	0,043
Zagrzeb Croatia	Winter 2008	4,91	3,64	0,016
	Summer 2007	0,14	0,10	0,001
Florence Italy	Winter 2009/2010	2,17	5,43	0,012
	Summer 2009/2010	0,54	1,54	0,003

**MEQ** – mutagenic equivalent

**CEQ** – carcinogenic equivalent

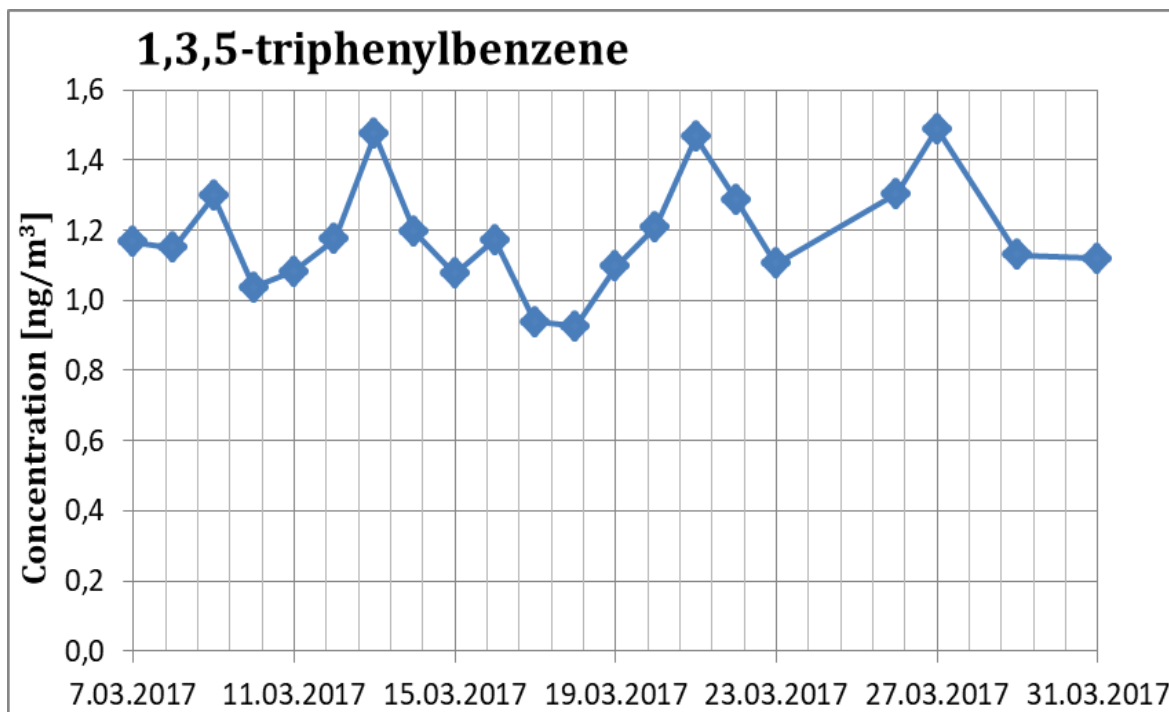
**TEQ** – toxic equivalent

March	
(A) Total concentrations of carcinogenic hydrocarbons, ng/m <sup>3</sup>	70,10
(B) Total concentrations of all aromatic hydrocarbons, ng/m <sup>3</sup>	84,14
Ratio (A) / (B)	<b>0,83</b>
August	
(A) Total concentrations of carcinogenic hydrocarbons, ng/m <sup>3</sup>	9,42
(B) Total concentrations of all aromatic hydrocarbons, ng/m <sup>3</sup>	10,62
Ratio (A) / (B)	<b>0,89</b>

# Emerging contaminant

# 1,3,5 - triphenylbenzene

March



In March, for the first week, the concentration of 1,3,5-triphenyl benzene in the air remained constant at 0,31 ng/m<sup>3</sup>.

August

Chemical compound	Concentration of 135TFB in individual weeks, ng/m <sup>3</sup>					Average concentration ng/m <sup>3</sup>	
	01-06	07-13	14-20	21-27	28-31	March	August
1,3,5-triphenylbenzene	0,26	0,26	0,26	0,34	0,31	0,99	0,29



## Conclusions

1. The concentrations of PM10 in March was much above the daily limit value ( $50\mu\text{g}/\text{m}^3$ )(**15 days**). In August, concentration of PM10 did not exceed the acceptable standards. Acceptable level of PM10 may be exceeded within a year for **35 days**. Higher daily temperatures and higher wind speed were conducive to the occurrence of lower concentrations of PM10.
2. The average concentration of OC and EC recorded in colder month of 2017 was  **$19,38\mu\text{g}/\text{m}^3$**  and  **$4,28\mu\text{g}/\text{m}^3$** , while in warmer month was  **$6,79\mu\text{g}/\text{m}^3$**  and  **$1,79\mu\text{g}/\text{m}^3$** .
3. Concentrations of PAHs in March ( **$84,14\text{ng}/\text{m}^3$** ) was 8 times higher than in August ( **$10,62\text{ng}/\text{m}^3$** ).
4. The analyses showed an 7 times higher concentration of carcinogenic PAHs in March ( **$70,10\text{ng}/\text{m}^3$** ) than in August ( **$9,42\text{ng}/\text{m}^3$** ).
5. Analyses confirmed the presence of 1,3,5-triphenylbenzene, in whole measuring period, and its average concentration was  **$0,99\text{ng}/\text{m}^3$**  and  **$0,29\text{ng}/\text{m}^3$** , in March and August, respectively.

135TPB is one of many exhaust gas components caused by burning of polyethylene plastics (mainly plastic bags).

# Thank you for your attention

## Acknowledgement

This presentation is based upon work from COST Action COLOSSAL supported by COST (European Cooperation in Science and Technology)