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Research Article

POSSIBLE USE OF SPIDER WEBS FOR THE INDICATION OF ORGANIC ROAD POLLUTANTS

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ABSTRACT
The results of the research assessing the possibility of using spider webs for the indication of organic pollutants (PAHs) in the long period of time in the air polluted with road traffic emissions are presented. It was proved that webs could be used for the indication of pollutants of this type. Because of the great availability and dense structure of webs belonging to representatives of Agelenidae family, they can serve as a very effective tool. What is more, the secluded location of webs is favorable and influences the accuracy and credibility of results, since deposited pollutants are not washed off with rain, neither are they decomposed by microorganisms or sunlight. The influence of co-existing contaminants is also minimized.

Keywords: PAHs, road pollutants, spider webs, indication.

INTRODUCTION

Already for a long time, the biomonitoring methods support the instrumental monitoring techniques of mosses, vascular plants and lichens are usually used to evaluate the pollution of atmospheric aerosol [Ciesielczuk et al. 2012]. Spider webs absorb air pollution thus they can also serve as a perfect tool in the environment assessment. Advantages of the use of webs are as follows: a low cost of samples collections, great availability of the research material, sheltered location of webs preventing them from destruction by weather conditions (rain, wind, sun), non-invasiveness of studies, an easy sample collection [Rybak 2012, Rybak et al. 2012, Rybak and Olejniczak 2013]. The ability of webs to accumulate toxins enables a long-term assessment of air pollution level in the selected site, which is an additional advantage, in contrast to standard measurements which provide information about the temporary state of the environment only. Thus, spider webs can serve as a perfect indicator of air pollution level [Rybak 2012, Rybak et al. 2012, Rybak and Olejniczak 2013, Xiao et al. 2006].

The aim of studies was to test the hypothesis if spider webs are suitable for the assessment of air contamination with polycyclic aromatic hydrocarbons in a long period of time. PAH concentrations are dependent on the nature of emissions to the atmosphere, as well as on rates of wet and dry deposition, sunlight, wind and chemical transformations. Thus, the accumulation rates depends on the site location. Research of this type focusing on application of spider silk for the indication of pollutants were done several times only [Hose at al. 2002, Rybak 2012, Rybak et al. 2012, Rybak and Olejniczak 2013, Xiao et al. 2006]. Listed authors (with the exception of Rybak and Olejniczak 2013) were not focused on PAHs. The work of Rybak and Olejniczak [2013] proved that spider webs of Agelenidae family are good for indication of road traffic emissions concerning PAHs (of high molecular weight mainly) previously defined as markers of traffic contamination (as benzo[*a*]pyrene, pyrene, fluoranthene and phenanthrene and others such as benzo[*a*] anthracene and indeno[*1,2,3-c,d*]pyrene that may also serve this role). The cited work focused on the possibility of indication with the use of spider webs (only from Agelenidae family exposed for

60 day at sampling sites) and, what is more, on finding possible PAHs sources. In the presented work the accumulation of PAHs is studied in 5 different spider species in long time period (the webs were exposed at sampling sites during 10, 60 and 90 days).

MATERIAL AND METHODS

The research were conducted in 2010 (spring, summer, autumn), 8 sites were chosen for studies within the city of Wrocław. As many as 5 species from Agelenidae family: *Malthonica silvestis* (L. KOCH, 1872), *Malthonica ferruginea* (PANZER, 1804), Amaurobiidae family: *Amaurobius ferox* (WALCKENAER, 1830) and finally Theridiidae: *Theridion mystaceum* L. KOCH, 1870 and *Theridion melanurum* HAHN, 1831 were selected. They were not present at all sites. Species that do not eat their own old web were chosen. Hose's studies (2002) proved that some pollutants (mainly heavy metals) are deposited on the web, but they are not built in into the matrix of Cribellatae webs. Probably, these observation could be also true for other spider species. What is more, spider silk is a protein product dependent on food spiders food. Hence, the contaminated food can affect the contamination of predators body and, in consequence, it might be present in their webs, as spiders prey can derive from a larger area than their victims. But spiders from Agelenidae, Amaurobiidae and Theridiidae families feed mainly on non-flying insects and other invertebrates (some beetles, springtails, ants and earthworms) which do not travel such long distances as flying insects do [Park and Moon 2012].

Samples were collected in the city of Wrocław (Lower Silesia, SW Poland). Two types of webs were used for the analysis: dry silk of Cribellatae representatives such as Amaurobiidae and sticky or dry of Ecribellatae such as Theridiidae and Agelenidae. For chemical analyses only newly constructed webs were used after 10 and 60 and 90 days of exposure. Webs of similar size and weight were used [Hose at al. 2002]. They were collected from walls of hydrotechnical building protected from rain in a great distance from the main routes (reference site 1), from walls and fences of housing estate away from heavy traffic (reference site 2), from the wall of an underground car park about 15 meters (site 3) and about 70 meters away (site 4) from a highly traffic road, from railway viaducts walls situated in a quiet area but in the vicinity of heavy traffic roads (site 5 and site 6) and from fences and hedges along a busy street contributing highly to the worst pollution in the city of Wrocław by road emissions [WIOŚ 2012], samples were collected about 10 meters (site 7) and about 70 meters (site 8) away from the roadside [Rybak 2012, Rybak et al. 2012, Rybak and Olejniczak 2013]. Figure 1 presents the map of sampling sites.

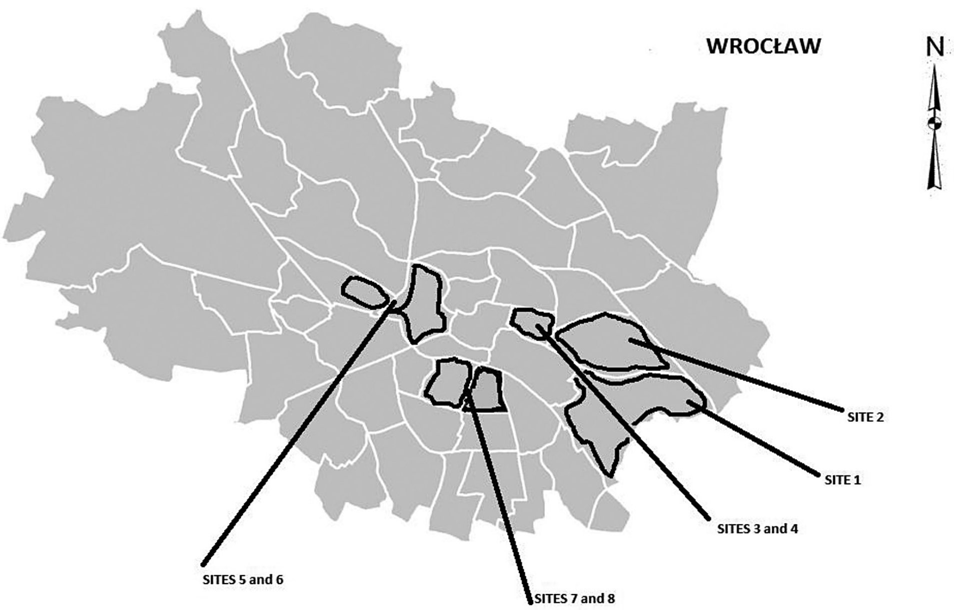

Figure 1. The map of sampling sites (map modified on the basis: [http://commons.wikimedia.org/wiki/File:Wroc%C5%82aw_Huby.png, [Siliesiac] (Category:Districts of Wrocław), licencja: [CC-BY-SA 3.0 Deed] (link do: http://creativecommons.org/licenses/by-sa/3.0/)

The silk was collected into clean glass phials with glass, sterile baguettes and then frozen until their use for chemical analyses. PAHs content was determined with chromatograph GC-MS of the absolute calibration for PAHs standards and average sensitivity 0.1 ng/50 µl (examined solution, i.e. 0,002 µg/ml). The samples were extracted with three portions (1 ml) mixtures of methylene chloride with methanol (9:1 v/v). Extracts after spinning (10 000 rpm) were evaporated to a dry residue in the stream of nitrogen (temp. 30 °C) and then dissolved in 50 µl of methylene chloride and analyzed. A qualitative and quantitative analysis of organic pollutants included in samples was done by Chemical Department in the University of Wrocław [Rybak and Olejniczak 2013]. Sixteen polycyclic aromatic hydrocarbons were determined in the samples according to US EPA recommendation. Table 1 shows names and corresponding recovery rates (RR) and standard deviations (SD_{RR}) [Rybak & Olejniczak 2013].

Non-parametric (Wilcoxon signed-rank Test, Mann-Whitney U-Test) statistical tests were used because the data were only partly normally distributed. Statistical tests were performed to determine differences in PAHs content between months of observation and between distance from emission source and among spider webs types. The probability level (p) of all tests was 0.05.

Table 1. Names, recovery rates RR and standard deviation (SD_{RR}) for corresponding PAHs in the web samples (n= 6) [Rybak & Olejniczak 2013]

PAH	RR [%]	SD_{RR}
Naphthalene	75.3	12.4
Acenaphthylene	89.5	5.3
Acenaphthene	98.7	8.9
Fluorene	99.4	12.1
Phenanthrene	87.3	13.4
Anthracene	88.7	6.2
Fluoranthene	98.1	16.1
Pyrene	91	8.2
Benzo[*a*]anthracene	89.2	14.2
Chrysene	93.1	12.5
Benzo[*b*]fluoranthene	95.3	7.8
Benzo[*k*]fluoranthene	96.4	6.5
Benzo[*a*]pyrene	90.1	9.9
Indeno[*1,2,3-c,d*]pyrene	99.6	15.7
Dibenzo[*a,h*]anthracene	95.4	11.8
Benzo[*g,h,i*]perylene	82.7	12.5

RESULTS AND DISCUSSION

PAHs content at sites in 2010 for the genus *Malthonica* (Agelenidae family), *Amaurobius ferox* (Amaurobiidae family), for the genus *Theridion* (Theridiidae family) are shown in Tables 2, 3, 4 and 5.

PAH concentrations according to Wilcoxon signed-rank Test for June, July and October 2010 differed significantly (for *Malthonica* genus: June-July Z = -5,009; June-October Z = -5.25; July-October Z = -5.84; p = 0,001; for *Amaurobius ferox*: June-July Z = -4.45; June-October Z = -3.79; July-October Z = -3.79; p = 0,001; for *Theridion* genus: June-July Z = -4.23; June-October Z = -4.45, July - October Z = -4.45 p = 0,001). PAHs concentrations according to Mann-Whitney U-Test were not significantly different between site 3 and 4 (U = 165.0, p = 0.56), but they were significantly different between site 7 and 8 (U = 13, p = 0.01) proving that the average concentrations of PAHs decrease with the distance from roadside.

As it was shown in Tables 3 and 4 the differences between the same sites (site 5 and 6) and different species (dry silk of *Amaurobius ferox*, and sticky silk of genus *Theridion*) were not significantly different (p > 0.05 Mann-Whitney U-Test). The highest concentrations of PAH were observed at sites with the heaviest traffic. The total PAH concentration, Σ PAH in web samples exposed for 10 days in reference site 2 (ΣPAH =787 ng/g) was comparable with the mean ΣPAH of 827 ng/g determined in the moss *Pseudoscleropodium purum* exposed for 2 months in Santa Cruz city on the Tenerife islands [Ares et al. 2009], but the total concentrations of PAHs in the reference site 1 exposed for 10 days (ΣPAH = 85 ng/g) are comparable with those in control samples of mosses *Pleurozium schreberi* exposed for 7 days (ΣPAH= 99 ng/g) and collected in the areas of Kotorz village in Poland, characterized with little pollution [Ciesielczuk et al. 2013]. The highest values of PAHs were obtained for highly traffic oriented site 7, webs exposed for 90 days contained 11786 ng/g ΣPAH. Such a result is not comparable with others obtained with the use of mosses and lichens or vascular plants, as these biomonitors were not exposed for such a long time. In this context spider webs seem to be more efficient when evaluating long-term air condition, then other biomonitors dependent on water and sun. In general, roadway tunnel, viaducts and car

Table 2. Mean concentrations and standard deviation of PAHs at sites in 2010, the samples were collected in June (I data series for 6 sites) after 10 days of exposure for genus *Malthonica.* L. d. = below detection limit. Concentrations are given in ng/g dry weight (n = 5)

PAH [ng/g]	Site no. 1(i)	Site no. 2(i)	Site no. 3(i)	Site no. 4(i)	Site no. 7 (i)	Site no. 8(i)
Naphthalene	L. d.	5.1±2.2	24.92±1.1	1.4±0.12	12.97±0.3	3.18±0.04
Acenaphthylene	L. d.	L. d.	L. d	L. d	34.71±4.64	15.34±1.8
Acenaphthene	L. d.	L. d.	L. d.	19.35±3.1	11.03±2.3	L. d.
Fluorene	L. d.	10.83±7.8	L. d.	34.45±7.9	18.23±4.3	L. d.
Phenanthrene	L. d.	8.9±3.5	140.92±35.8	129.99±23.1	200.11±13.2	10.21±2.8
Antheracene	L. d.	13.6±1.6	65.16±12.3	20.61±2.5	411.75±19.2	211.22±12.1
Fluoranthene	16.18±3.1	341.8±61.5	144.77±9.0	170.13±54.9	534.42±13.4	307.6±11.7
Pyrene	34.33±2.2	28.12±7.4	29.85±12.0	27.5±11.5	604.36±11.23	345.32±12.8
Benz[a]anthracene	L. d.	11.55±6.1	174.62±12.2	98.88±15.7	715.12±21.6	245.36±33.7
Chrysene	11.05±1.1	16.21±1.8	119.4±6.9	89.26±9.9	664.9±23.1	165.12±13.1
Benzo[b]fluoranthene	L. d.	17.76±4.1	121.84±15.8	107.45±43.8	300±12.7	121.21±18.6
Benzo[k]fluoranthene	L. d.	12.12±2.7	L. d.	L. d.	L. d.	L. d
Benzo[a]pyrene	24.41±7.3	28.67±9.5	L. d.	41.34±13.91	915.43±12.3	343.12±16.3
Indeno[1,2,3-c,d]pyrene	L. d.	L. d	179.1±21.3	167.66±27.36	555.35±12.8	332.66±32.11
Dibenz[a,h]anthracene	L. d.	19.12±5.2	L. d.	L. d.	306.57±26.1	105.83±9.1
Benzo[g,h,i]perylene	L. d.	273.46±17.5	L. d	L. d.	567.16±23.3	326.5±56.1
Sum of PAHs	85.97±13.7	787.24±128.7	1000.58±126.4	908.02±213.79	5852.11±200.47	2532.67±220.25

Table 3. Mean concentrations and standard deviation of PAHs at sites in 2010, the samples were collected in July (II data series for 4 sites) after 60 days and in October (III data series for 4 sites) after 90 days of exposure for genus *Malthonica.* L. d. = below detection limit. Concentrations are given in ng/g dry weight (n = 5)

PAH[ng/g]	Site no. 1 (II)	Site no. 2(II)	Site no. 3(II)	Site no. 7(II)	Site no. 1 (III)	Site no. 2(III)	Site no. 3(III)	Site no. 7(III)
Naphthalene	L. d.	9.8±4.7	2.9±1	27.14±7.71	L. d.	46.41±12.67	12.31±5.78	45.12±9.18
Acenaphthylene	L. d.	L. d.	L. d	91.74±6.31	L. d.	L. d.	L. d	221.65±128.91
Acenaphthene	L. d.	L. d.	69.86±1.9	57.87±12.61	L. d.	L. d.	110.71±23.08	137.16±54.11
Fluorene	L. d.	15.84±4.1	156.78±11.8	67.34±11.05	L. d.	61.27±23.86	273.91±32.17	168.23±47.51
Phenanthrene	L. d.	38.5±10	414.17±18.3	544.54±34.21	L. d.	159.67±28.13	503.22±127.83	714.86±141.28
Antheracene	L. d.	23.19±6.9	58.12±7.91	790.25±40.2	L. d.	76.11±18.19	108.27±19.17	1095.54±185.52
Fluoranthene	58.8±14.8	567.53±27.1	674.76±7.65	890.8±43.31	90.12±23.91	1062.63±48.92	903.11±123.5	1190.12±143.16
Pyrene	67.14±18.7	39.7±4.14	98.51±11.7	1005.16±33.6	158.41±34.63	103.62±17.13	180.43±55.12	1075.33±234.62
Benz[a]anthracene	L. d.	100.2±23.1	234.1±10.14	990.45±16.8	L. d.	159.98±90.6	404.87±154.08	990.45±16.8
Chrysene	48.14±18.6	36.32±5.7	321.56±19.2	1007.37±45.18	109.21±27.32	166.98±11	508.76±122.71	1142.71±167.16
Benzo[b]fluoranthene	L. d.	47.63±4.1	567.89±34.2	691.75±23.48	L. d.	199.12±23.67	718.73±187.06	792.53±123.9
Benzo[k]fluoranthene	L. d.	34.43±4.6	L. d.	L. d.	L. d.	140.78±41.87	L. d.	L. d.
Benzo[a]pyrene	145.67±12.3	103.56±7.1	190±12.33	1434.66±58.12	242.22±67.18	257.84±55.1	345.13±167.18	1523.78±169.23
Indeno[1,2,3-c,d] pyrene	L. d.	L. d	589.15±67.03	771.45±23.32	L. d.	L. d	719.63±168.14	883.31±134.41
Dibenz[a,h]anthracene	L. d.	49.12±12.2	L. d.	712.3±69.8	L. d.	204.13±56.13	L. d.	813.72±173.15
Benzo[g,h,i]perylene	L. d.	516.42±34.5	L. d.	898.56±12.13	L. d.	1061.23±43.02	L. d.	991.62±138.34
Sum of PAHs	319.7±64.4	1572.44±143.5	3374.9±202.16	9981.38±437.83	599.96±153.04	3699.77±470.29	4789.08±1215.82	11786.13±1867.27

Table 4. Mean concentrations and standard deviation of PAHs at sites in 2010, the samples were collected in June (I data series for 2 sites) after 10 days, in July (II data series for 2 sites) after 60 days and in the October (III data series for 2 sites) after 90 days of exposure for *Amaurobius ferox.* L. d. = below detection limit. Concentrations are given in ng/g dry weight (n = 5). No significant differences were found between concentrations of PAH for *Amaurobius ferox* and genus *Theridion* at sites (Table 4) 5 and 6 (p <0.05 Mann-Whitney U-Test)

PAH [ng/g]	Site no. 5 (I)	Site no. 6 (I)	Site no. 5 (II)	Site no. 6(II)	Site no. 5 (III)	Site no. 6(III)
Naphthalene	10.05±1.2	7.17±2.3	27.89±6.8	31.54±8.84	56.42±15.12	78.31±19.71
Acenaphthylene	14.02±4.32	L. d.	56.8±13.98	7.82±1.07	89.63±24.07	19.35±10.83
Acenaphthene	L. d.	L. d.	L. d.	L. d.	L. d.	L. d.
Fluorene	13.46±2.86	7.1±4.81	35.43±6.74	69.23±12.43	148.32±16.22	193.24±126.67
Phenanthrene	107.01±23.77	24.53±4.16	534.71±78.12	90.34±16.12	931.63±145.36	207.76±53.16
Antheracene	23.55±4.23	63.77±4.07	101.97±12.5	321.87±56.9	238.74±29.71	512.76±147.02
Fluoranthene	128.04±17.98	72.64±23.6	719.18±48.57	261.6±47.16	852.72±89.61	418.72±158.72
Pyrene	217.29±22.79	171.7±45.92	827.07±83	432.41±65.37	1116.18±193.28	602.3±197.03
Benz[a]anthracene	348.6±54.73	541.51±53.15	548.31±67.38	678.43±19.86	739.42±175.83	964.27±120.95
Chrysene	335.05±12.27	170.75±47.02	909.89±23.14	684.13±16.62	1093.76±132.44	975.24±182.41
Benzo[b]fluoranthene	44.39±43.96	272.64±13.09	178.19±19.24	608.1±65.38	369.86±122.31	851.14±78.22
Benzo[k]fluoranthene	71.96±13.6	L. d.	191.52±26.07	2.52±0.8	493.3±137.83	13.21±4.15
Benzo[a]pyrene	349.07±12.09	198.11±38.08	581.41±45.97	456.12±56.76	702.32±162.86	632.37±179.17
Indeno[1,2,3-c,d]pyrene	97.2±12.66	43.4±12.06	108.12±42.11	105.9±22.8	295.34±161.78	236.82±76.63
Dibenz[a,h]anthracene	135.05±18.94	47.17±2.76	167.89±34.8	181.54±48.12	289.19±146.17	472.28±127.52
Benzo[g,h,i]perylene	514.02±67.9	10.75±0.78	794.12±49.03	56.33±25	881.33±156.17	106.18±33.27
Sum of PAHs	2408.76±313.3	1631.24±251.7	5782.5±557.45	3987.88±406.47	8249.16±1339.12	6574.85±1515.46

Table 5. Mean concentrations and standard deviation of PAHs at sites in 2010, the samples were collected in June (I data series for 2 sites) after 10 days, in July (II data series for 2 sites) after 60 days and in the October (III data series for 2 sites) after 90 days of exposure for genus *Theridion.* L. d. = below detection limit. Concentrations are given in ng/g dry weight (n = 4)

PAH [ng/g]	Site no. 5 (i)	Site no. 6(i)	Site no. 5 (ii)	Site no. 6(ii)	Site no. 5 (iii)	Site no. 6(iii)
Naphthalene	18.52±2.56	18.05±3.14	34.12±6.12	39.16±2.85	157.18±32.82	80.54±23.92
Acenaphthylene	17.04±4.07	3.05±0.98	68.18±10.65	8.19±2.33	195.37±32.18	31.27±12.56
Acenaphthene	L. d.	L. d.	L. d.	L. d.	L. d.	L. d.
Fluorene	16.12±1.9	3.61±0.7	44.27±5.93	78.31±9.3	181.19±67.12	179.63±39.84
Phenanthrene	106.3±26.04	34.66±12.76	598.6±66.01	100.66±6.51	1074.03±213.8	269.71±69.62
Antheracene	31.85±12.55	75.81±1.64	115.09±45.4	373.51±65.23	226.1±155.32	691.72±126.48
Fluoranthene	125.93±27.04	102.35±23.14	690.23±61.31	251.69±41.49	1031.47±123.43	362.78±156.98
Pyrene	188.89±66.43	116.25±23.33	749.43±77.12	386.52±71.32	1050.64±186.23	889.43±160.44
Benz[a]anthracene	355.56±55.17	453.43±45.78	491.64±43.51	699.56±67.12	809.75±154.62	1409.51±186.19
Chrysene	407.41±100.67	214.44±56.89	897.32±44.12	707.3±45.13	1207.43±164.03	1432.06±87.31
Benzo[b]fluoranthene	59.26±12.77	178.7±34.45	199.2±18.07	643.24±34.36	439.37±40.09	1442.7±139.28
Benzo[k]fluoranthene	59.63±13.1	L. d.	187.31±35.12	3.16±1.1	406.42±73.31	12.26±6.79
Benzo[a]pyrene	205.56±67.89	166.68±28.9	600.2±56.89	512.1±66.93	1090.53±118.07	1067.18±165.06
Indeno[1,2,3-c,d]pyrene	105.7±20.5	36.61±13.42	191.37±32.2	107.23±12.65	467.48±64.46	268.34±59.17
Dibenz[a,h]anthracene	86.52±7.62	38.31±12.55	178.22±22.9	191.38±43.21	463.36±67.76	467.78±89.12
Benzo[g,h,i]perylene	270.04±24.09	8.05±2.37	762.13±56.18	65.1±18.07	1160.47±103.18	145.7±36.62
Sum of PAHs	2054.31±442.4	1450±260.05	5807.31±581.53	4167.11±487.6	9960.79±1596.42	8750.61±1359.38

park (sites 3, 4, 5, 6, 7 and 8) are characterized by the specific air circulation and are sheltered from the rainfall, which effectively protect walls before gradual removing of accumulated pollutants. Unfortunately, the silk of all used species, with the exception of the Agelenidae family, was rarely available in urban environment what seems to be the additional obstacle in the potential use of these webs for air monitoring. It seems that all Agelenids are very suitable for organic pollutants indication, since the representatives can be identified relatively easily and they produce an extensive, easily recognizable webs. Most importantly, they are active all-year-round, even in low temperatures and their webs are resistant to degradation of any type [Roberts 1995, Rybak 2012, Rybak et al. 2012, Rybak and Olejniczak 2013].

The concentration of PAHs depends on traffic intensity, the distance from the emission sources, meteorological conditions, the size of the particulates and their rates of deposition [Jones et al. 1989, Kumar et al. 2011, Oliveira et al. 2011]. The mechanism of PAHs accumulation depends upon their chemical and physical properties and the environmental conditions. PAHs dispersion in the atmosphere is divided between the gas phase (PAHs of high volatility) and particulate matter (the least volatile compounds with 5, 6 rings), PAHs of medium volatility (with 3 or 4 rings) are distributed between the gas and particulate phases [Harmens et al. 2013]. Compounds in gas phase are transported to the areas much distant from pollution sources, whereas solid particulate absorbed PAHs are deposited in great amounts near the emission source [Harmens et al. 2013, Thomas 1986]. The degradation rate of PAHs is generally very slow and depends upon several factors [Kumar et al 2011]. But they could easily decompose as result of the activity of microorganisms and sunlight [Chen et al. 2010]. However, photolysis is much lower for PAHs presented in the atmospheric particulate matter (PM) than in water or organic solvents [Tobiszewski and Namieśnik 2012]. As significant differences were observed in PAHs content depending on the exposure time, we can say that the location of sites (places sheltered from rain and sunlight) was the main factor stimulating the constant accumulation process. The pollutants of this type can migrate for significant distances. On the other hand, a decrease of PAHs content was observed near emission sources caused by a strong wind [Cabrerizo et al. 2012]. In the presented studies factors influencing or disturbing PAHs accumulation were eliminated (sheltered places), therefore, a statistically significant decrease of PAH concentrations was observed along with increasing the distance from the heavy traffic roadside (sites 7 and 8). In earlier conducted studies, the authors proved that active monitoring with the use of mosses in roadside tunnels is the most effective when monitoring road pollutants [Harmens et al. 2013, Zechmeister et al. 2006].

CONCLUSION

The results presented proved that webs can serve as an effective long term tool for the indication and evaluation of air pollutants, such as polycyclic aromatic hydrocarbons. The spider webs-based studies of air pollution are very small by scale compared with studies based on other bioindicators such as mosses, lichens and vascular plants. Because of their excellent accumulative properties resulting from webs high density, the webs of Agelenidae representatives can serve as an easy indication tool, applied almost all-year-round, what seems to be an additional advantage comparing to bioindicative methods often limited to the vegetative season. The recorded high concentrations of PAHs (with the exception of reference sites 1 and 2) were highly traffic oriented. All sampling sites were protected from rain washing giving them the possibility to accumulate PAHs in a long period of time (decomposition processes are limited). As the webs are not dependent on sunlight, their use seems to be favorable than other commonly used biomonitors, protecting PAHs from their fast degradation. What is more, the relation between concentrations of PAHs in atmospheric aerosol and accumulated in webs has never been studied, thus further studies are required.

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