Source Assessment and Sedimentary Record of Pyrolytic Polycyclic Aromatic Hydrocarbons in Lake Bled (NW Slovenia)

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Abstract

Polycyclic aromatic hydrocarbons (PAH) were determined in two sediment cores in urban Lake Bled (NW Slovenia). In surface sediments of the deep western basin, the total PAH concentration was 1150 ng g^{-1} dry weight (dw), whereas in shallower, nearshore Zaka Bay the PAH concentration was 1900 ng g^{-1} dw. Four- to six-ring PAH were the most abundant compounds, suggesting that most PAH in Lake Bled sediments are pyrogenic, probably of coal combustion origin as inferred by several PAH ratios. Uniform compositions for pyrogenic PAH were observed downcore in both cores. The highest concentrations of PAH in Lake Bled sediments occurred in sediments deposited in mid 20th Century (ca. 1945), leading to organic carbon (OC) normalized concentrations of 120 µg PAH g^{-1} OC, compared to contemporary concentrations of 21 and 30 µg g^{-1} OC in the western basin and Zaka Bay, respectively. Using PAH concentrations and sedimentation rates, we estimate that present-day PAH fluxes are 630 and 1800 µg m^{-2} yr^{-1}, respectively. These contemporary PAH fluxes to Lake Bled were still 3–4 fold higher than in nearby but remote alpine Lake Planina, confirming elevated PAH contamination in the urban setting.

Keywords: PAH; black carbon; combustion; Pollution

1. Introduction

Polycyclic aromatic hydrocarbons (PAH) are hydrophobic compounds comprised of two or more fused benzene rings. These compounds are of particular environmental and health concern because they are toxic and potentially carcinogenic and mutagenic.[1] In general, PAH originate from three sources, i.e. high-temperature combustion (pyrogenic PAH) of fossil or biomass fuels, low-temperature catagenesis over geologically long periods of time (petrogenic PAH), and microbial modification of biogenic precursors over geologically short periods of time (diagenetic PAH).[2]

PAH released to the atmosphere are distributed between the gas and particulate phases, depending on their physico-chemical properties and may be widely dispersed and transported long distances. As a consequence, they are ubiquitous and are found throughout the world, in urban as well as in remote locations.[3,4,5] The hydrophobic nature and stability of PAH with respect to both biotic and abiotic degradation allow PAH to accumulate in aquatic sediments, and hence local (regional) pollution history, effects of growing population, and changing combustion practices can be assessed based on temporal distributions of sedimentary PAH.

The aim of the paper is to characterize PAH in Lake Bled sediments. Parent (non-alkylated) and alkylated PAH homologs were measured and several PAH ratios were calculated to assess sources (pyrolytic vs. petrogenic origin) of PAH. PAH concentrations were compared to concentrations of black carbon (BC) in Lake Bled sediments to study the possible association of PAH to BC. Finally, depth profiles of sedimentary PAH provide a historical record of environmental pollution history of the Lake Bled watershed, and thus we could estimate and compare the level of PAH contamination in Lake Bled area with other areas. These data are important for evaluating the transport and fate of PAH, as well as health issues related to their presence in the environment.

2. Experimental

2. 1. Site Description and Sampling

Lake Bled (46° 22' 30'' N, 14° 07' 30'' E) is a glacial subalpine lake in an urban area of NW Slovenia (Fig. 1). The lake lies at 475 m above sea level and has a surface area of 1.47 km^2. Lake Bled has two surface inflows (Misca and Solznik) and one outflow (Jezernica). Two basins are separated by an island; a deeper western basin (30 m depth), and an eastern basin (24 m deep). The western part of the lake has also a shallow embayment (Zaka Bay) with a depth of approximately 15 m.
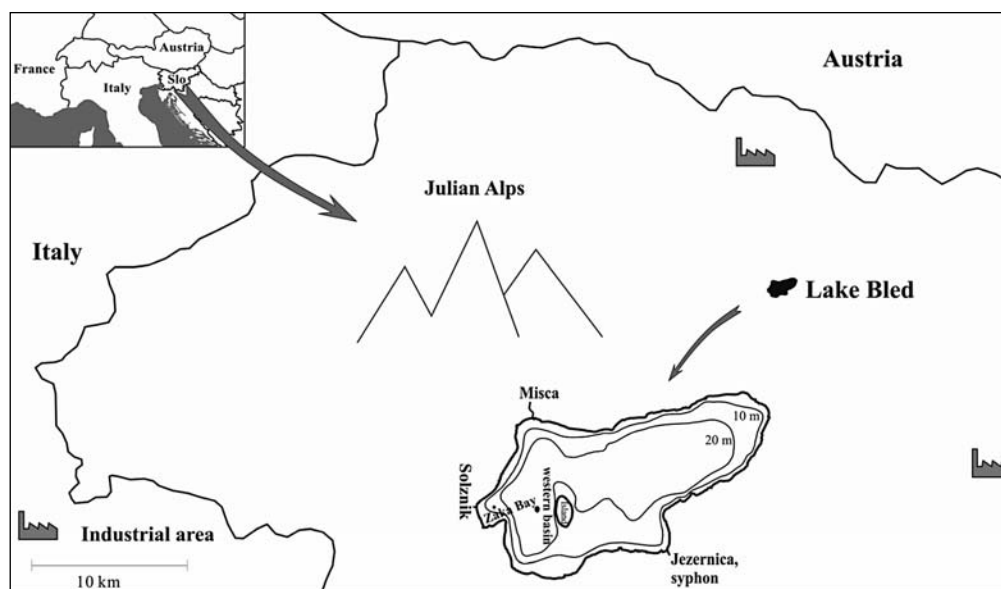
10–20 µm.[7] There are, however, slight differences in grain size distributions between the two sampling locations. Although silt dominates both sediments (45% in the western basin and 58% in Zaka Bay), clay was less abundant (40 vs. 9%, respectively) in Zaka Bay. The remainder is sand (Cermelj, personal communication).

2. 2. Analyses

Sediments were analyzed for 14 parent (non-alkylated) PAH, i.e. phenanthrene + anthracene (Ph+An), fluoranthene (Fl), pyrene (Py), benz[*a*]anthracene (BaA),

Figure 1: Environmental setting of Lake Bled and location of the sampling points (the western basin and Zaka Bay).

Although Lake Bled is situated on the eastern-end foot of the Julian Alps (Fig. 1), it is affected by both direct and indirect anthropogenic activities. The lake is partly surrounded by the town of Bled (population of 5,500) with numerous streets along its shore and in its watershed. Several industrial installations are located in the lake's adjacent watershed (Fig. 1). In addition, long-range atmospheric transport from industrial areas to the west might contribute PAH to Lake Bled.[6]

Two sediment cores were collected in 2000 using a modified Kajak-Brinkhurst gravity corer equipped with a 70 cm × 6 cm diameter plexiglass tube. One core was collected in the deepest part of the lake – the western basin – and the second core in Zaka Bay. Sediments were extruded in the field and cut into one-cm slices. Core tubes, cutting utensils and glass jars were rinsed with distilled water, methanol and hexane in the laboratory and wrapped with aluminum foil to prevent contamination. Core sections were stored in glass jars, freeze-dried, homogenized and stored frozen until further analyses.

Grain size analysis shows that silt is the major fraction in Lake Bled sediments, with a mean grain size of

chrysene + triphenylene (Ch+Tr), retene (Re), benzofluoranthenes [b and k isomers] (BF), benzo[*e*]pyrene (BeP), benzo[*a*]pyrene (BaP), perylene (Per), indeno[1,2,3-*cd*] pyrene (IndP), benzo[*ghi*]perylene (BghiPer), dibenzanthracenes (DiBAn) and coronene (Cor) along with methyl (Me-Ph) and dimethyl (diMe-Ph) phenanthrenes. Details of the analytical procedure may be found elsewhere.[6] Briefly, dry sediment samples, spiked with perdeuterated PAH (phenanthrene-d_{10}, chrysene-d_{12} and perylene-d_{12}), were Soxhlet extracted with dichloromethane for 8–10 hours. Extracts were then concentrated by rotary evaporation, solvent was exchanged to hexane and extracts were fractionated on 5% deactivated silica. Aliphatic hydrocarbons were first eluted with hexane. PAH were eluted in the next two fractions using additional hexane and hexane/toluene (3:1). The two PAH fractions were combined, dried and redissolved in iso-octane prior to instrumental analyses. Procedural blanks were performed with each set of six samples. PAH were analyzed with a Hewlett Packard 5890 gas chromatograph coupled to a Finnigan Incos 50 mass spectrometer. A DB-5 column (30 m, 0.25 mm

i.d., 0.25 μm film thickness) was used for compound separation with helium as carrier gas. PAH were determined in selected ion monitoring (SIM) mode with ionization energy of 70 eV. The *m/z* peaks corresponding to the molecular weights of the individual PAH were used for identification and quantification. Concentrations of PAH were calculated relative to the perdeuterated surrogates.

Organic carbon (OC) concentrations in dry sediment samples were determined by adding HCl (1 M) until effervescence ceased and subsequently using a CHN elemental analyzer (Carlo Erba EA 1108) at a combustion temperature of 1020 °C.

Sediments were dated radiometrically using a γ-ray spectrometer equipped with a high purity Ge well-type detector to measure the ^{210}Pb and ^{137}Cs activities in each sediment slice. Sediment dating was obtained on the basis of unsupported ^{210}Pb activities using the constant rate of supply (CRS) model and confirmed by the ^{137}Cs profile.[7] Western basin sediments were not dated in this study, so we used an average sedimentation rate of 2.4 mm yr^{-1}.[7] The Zaka Bay core was dated in this study. Nearly uniform ^{210}Pb and ^{137}Cs activities in the upper ~8 cm of Zaka Bay sediments indicate intensive mixing, but sediments >8 cm depth yielded an average sedimentation rate of 4.5 mm yr^{-1} (unpublished data kindly provided by Dr. Z. Jeran).

3. Results

3. 1. Western Basin PAH

PAH distributions in surface and core-bottom sediments are shown in Fig. 2. Benzofluoranthenes were the most abundant compounds in the surface sediments (white bars). Overall, high molecular weight compounds (≥4 rings) were relatively more abundant than low molecular weight PAH. In contrast, benzofluoranthenes and fluoranthene were almost equally abundant in the deeper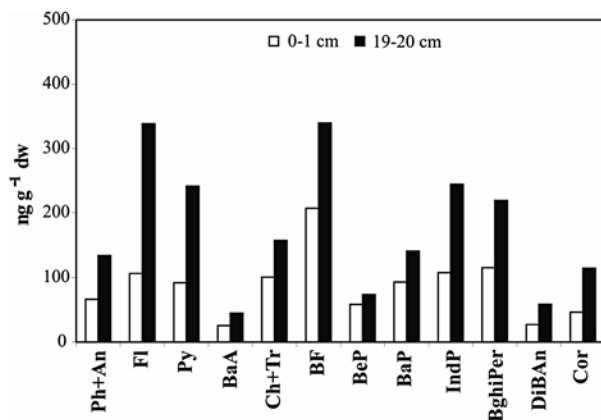 sediments, at a depth of 19–20 cm. Nonetheless, high molecular weight PAH still predominated over low molecular weight compounds even at the bottom of the core.

Total PAH concentration (PAH$_{tot}$; Fig 3a), calculated as the sum of parent PAH and methyl and dimethyl phenanthrenes, was 1150 ng g^{-1} dry weight (dw) sediment in the surface sediments of the western basin. Concentrations increased with depth to a maximum of 6270 ng g^{-1} dw at 12–13 cm but decreased to 2470 ng g^{-1} dw by 19–20 cm.
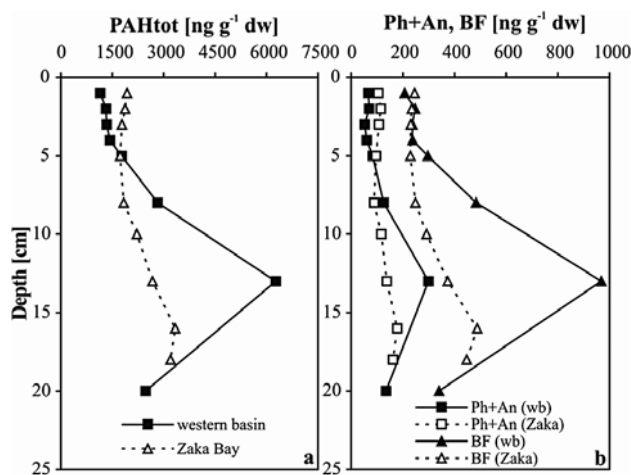

Figure 3: Depth profiles of (a) the total PAH concentration (PAH$_{tot}$) and (b) characteristic PAH of predominantly pyrolytic origin in the western basin (wb) and Zaka Bay (Zaka) sediments (Note that the time frame represented by the two cores is different).

Depth profiles for representative compounds of predominantly pyrolytic origin [i.e., phenanthrene + anthracene representing low molecular weight (three-aromatic ring) compounds, and benzofluoranthenes (b and k isomers) for high molecular weight (five-ring) compounds] are shown in Figure 3b. Concentrations of phenanthrene + anthracene were constant in the upper 4 cm of the sediment core averaging 60 ng g^{-1} dw, but rose to 300 ng g^{-1} dw at 12–13 cm before decreasing to 130 ng g^{-1} dw by 19–20 cm. The shape of the depth profile for benzofluoranthenes was similar to that of phenanthrene + anthracene. Concentrations of benzofluoranthenes in the upper sediments averaged ~230 ng g^{-1} dw, increased to 970 ng g^{-1} dw at 12–13 cm and then dropped to 340 ng g^{-1} dw at 19–20 cm.

3. 2. Zaka Bay PAH

Zaka Bay sediments exhibited a more uniform PAH composition throughout the sediment core (Fig. 4) than did the western basin core. Benzofluoranthenes and fluoranthene were again the most abundant compounds, but the predominance of high over low molecular weight PAH was less pronounced than in the western basin core.

Figure 2: Composition of PAH in the western basin sediments (Abbreviations as in section 2.2).

PAH_{tot} in Zaka Bay surface sediments (Fig. 3a) was higher than in the western basin one averaging 1830 ng g^{-1} dw in the upper 8 cm of the sediment. In the deeper sediments, PAH_{tot} increased to 3250 ng g^{-1} dw. There was no mid-depth concentration maximum.
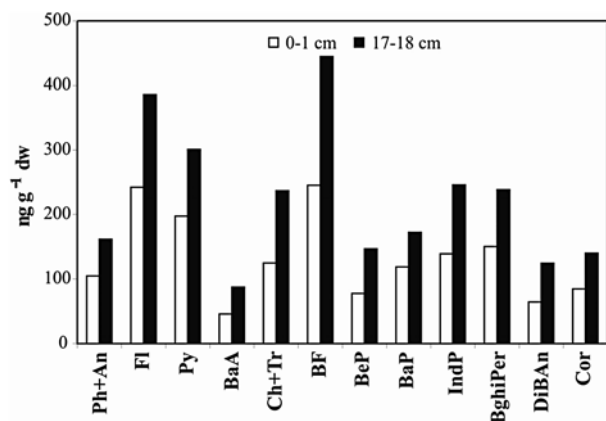

Figure 4: Composition of PAH in Zaka Bay sediments (Abbreviations as in section 2.2).

Concentrations of phenanthrene + anthracene (Fig. 3b) were uniform in the upper 8 cm of the sediment core, averaging 100 ng g^{-1} dw and increased slightly in the deeper sediments, to about 170 ng g^{-1} dw at the core bottom. The surface sediment concentration for benzofluoranthenes was 240 ng g^{-1} dw, while maximum concentrations observed in the deeper sediments were ~470 ng g^{-1} dw. However, the marked concentration maximum that was observed for phenanthrene + anthracene and benzofluoranthenes at 12–13 cm in the western basin core was not evident in Zaka Bay core; this might simply be due to a somewhat different time frame represented by the two cores (see discussion below).

4. Discussion

4. 1. Origin of PAH in Lake Bled Sediments

PAH may derive from pyrolytic, petrogenic, and short-term diagenetic sources. Apportionment between pyrogenic and petrogenic sources can be inferred by partitioning PAH into three groups by molecular weight (number of rings), i.e. three-, four- and five- to six-ring PAH. Five- to six-ring PAH were most abundant accounting for 48–61 and 45–50% of the PAH_{tot} in the western basin and Zaka Bay sediments, respectively. They were followed by four-ring PAH that comprised 28–38 and 29–32% of the PAH_{tot} and three-ring PAH that were 4–6 and 5–6% of the PAH_{tot} in the western basin and Zaka Bay, respectively. Four-ring and five- to six-ring PAH are generally attributed to pyrogenic sources.[8] Three-ring PAH are often ascribed as being petrogenic in origin.[8] Based on similar depth distributions of three- and five-ring PAH (Fig. 3b), howe-ver, we suggest that three-ring PAH in Lake Bled sediments are also primarily pyrolytic. Nonetheless, they were considerably less abundant, possibly reflecting a physico-chemical partitioning between low molecular weight and high molecular weight PAH during transport to the lake and subsequent sedimentation. Thus, high-temperature combustion is likely the major source of PAH in Lake Bled sediments. Relative abundances of the three groups were uniform throughout each core and between the core locations, suggesting that pyrogenic inputs dominated over other possible sources for the time spans represented by the cores, even as the source strengths varied so as to give significant concentration changes.

Ratios of alkylated to unsubstituted parent PAH (such as Me- and diMe-Ph to Ph) may also be used to assess whether PAH are of pyrogenic or petrogenic origin.[9] Petroleum PAH exhibit a higher abundance of alkyl homologues, while in PAH mixtures originating from high-temperature combustion processes unsubstituted homologues are more abundant. Thus, ratios of Me- and diMe-Ph to Ph for petroleum derived PAH range from 3 to 5,[9,10] while those of combustion derived PAH are lower, at around 0.5.[9,11] In Lake Bled sediments, all ratios were low. Me-Ph/Ph ratios ranged from 0.34 to 0.67 in the western basin, and in Zaka Bay were 0.47 to 0.71; diMe-Ph/Ph ratios ranged from 0.28 to 0.57 and from 0.37 to 0.53 in the western basin and Zaka Bay, respectively. Low alkyl Ph/Ph ratios in both sediment cores further support combustion sources as the prevailing contributors of PAH to Lake Bled. Furthermore, the unresolved complex mixture (UCM) of aliphatic hydrocarbons that is typical of petrogenic sources was not observed in the analyzed cores.[12]

PAH isomer ratios may also help to differentiate PAH derived from different types of high-temperature combustion, such as coal, oil and wood combustion, traffic sources etc. Nevertheless, the ratios should be treated with caution as biogeochemical and physical processes may alter PAH signatures due to variations in PAH reactivity, volatility, water solubility and sorption rates.[13,14] The Fl/(Fl+Py) ratio averaged 0.6 in Lake Bled sediments, consistent with coal as the dominant fuel since Fl/(Fl+Py) ratios between 0.5 to 0.8 are common for coal combustion.[15] On the other hand, petrogenic PAH usually exhibit ratios lower than 0.4.[14] Coal combustion may also be indicated by the IndP/(IndP+BghiPer) ratio that average 0.5 in Lake Bled, in accordance with the proposal by Yunker et al.[14] that IndP/(IndP+BghiPer) values from 0.5 to 0.6 result from coal combustion. Thus, several PAH ratios that encompass a range of masses suggested that PAH in Lake Bled sediments could predominately be derived from coal combustion.

4. 2. Assessment of Pollution History

The above discussion leads to the conclusion that pyrolytic sources dominate the PAH distributions in Lake Bled. Thus, total pyrolytic PAH concentrations (PAH_{pyr})

were calculated by subtracting concentrations of perylene, retene (these two PAH also have diagenetic origin) and alkyl phenanthrenes from the PAH_{tot} and may be used to assess pollution history. In all sediments, PAH_{pyr} closely followed PAH_{tot} since for most depths the sum of perylene + retene + alkyl phenanthrenes was usually less than 10–15% of PAH_{tot}. PAH_{pyr} in the western basin (plot not shown) was low in the upper sediments (1050 ng g^{-1} dw), exhibited a subsurface peak concentration of 5850 ng g^{-1} dw at 12–13 cm, and decreased to 2110 ng g^{-1} dw at 19–20 cm. On the other hand, PAH_{pyr} concentrations in Zaka Bay (plot not shown) were ~1500 ng g^{-1} dw in upper sediments and increased to about 2800 ng g^{-1} dw at the core-bottom.

PAH_{pyr} concentrations were used to estimate PAH fluxes into surface sediments. PAH accumulation rates were calculated by multiplying the respective PAH concentration, linear sedimentation rate, the density of the sediment and (1-Φ), where Φ is porosity. For the sediment density and porosity, we used the values of 2.5 g cm^{-3} and 0.9, respectively that were determined by Cermelj et al.[7] Sedimentation in the western basin was determined in the same study to be ~2.4 mm yr^{-1}, whereas in Zaka Bay a sedimentation rate of 4.5 mm yr^{-1} is assumed, using a sedimentation rate for sediments under the mixed upper 8 cm (Jeran, unpublished data). For the western basin, we thus

estimate a contemporary PAH flux of ~630 µg m^{-2} yr^{-1} and for Zaka Bay ~1800 µg m^{-2} yr^{-1}.

PAH_{pyr} concentrations may be compared with data from other environments, but to do so we have normalized PAH_{pyr} to OC concentration (PAH_{pyr}/OC). Doing so reduces confounding effects of sediment morphology (e.g., grain size, inorganic content) that might differ between Lake Bled and other sediments. In the western basin sediments, PAH_{pyr}/OC was low in the surface sediments (21 µg PAH_{pyr} g^{-1} OC) and increased downcore (Fig. 5a), peaking at 121 µg g^{-1} OC at 12–13 cm sediments that were deposited in the mid-20th century (~1945). At 19–20 cm that corresponds to approximately 1915, PAH_{pyr}/OC was 71 µg g^{-1} OC. PAH_{pyr}/OC in Zaka Bay sediments increased from ~30 µg g^{-1} OC in surface sediments to ~75 µg g^{-1} OC at the bottom of the core, deposited about 1960 (Fig. 5b).

The observation that OC-normalized PAH concentrations, and by inference fluxes of PAH to Lake Bled sediments, have decreased markedly during the late-20th century is consistent with PAH distribution patterns in other lakes located in the northern hemisphere.[3,4,5,17] In fact, it is possible that the absolute and OC-normalized concentrations in Lake Bled are actually higher than we measured since our sampling resolution was rather coarse. For comparison, PAH in Lake Planina, some 20 km from Lake Bled but in a remote area of the Julian Alps at an eleva-
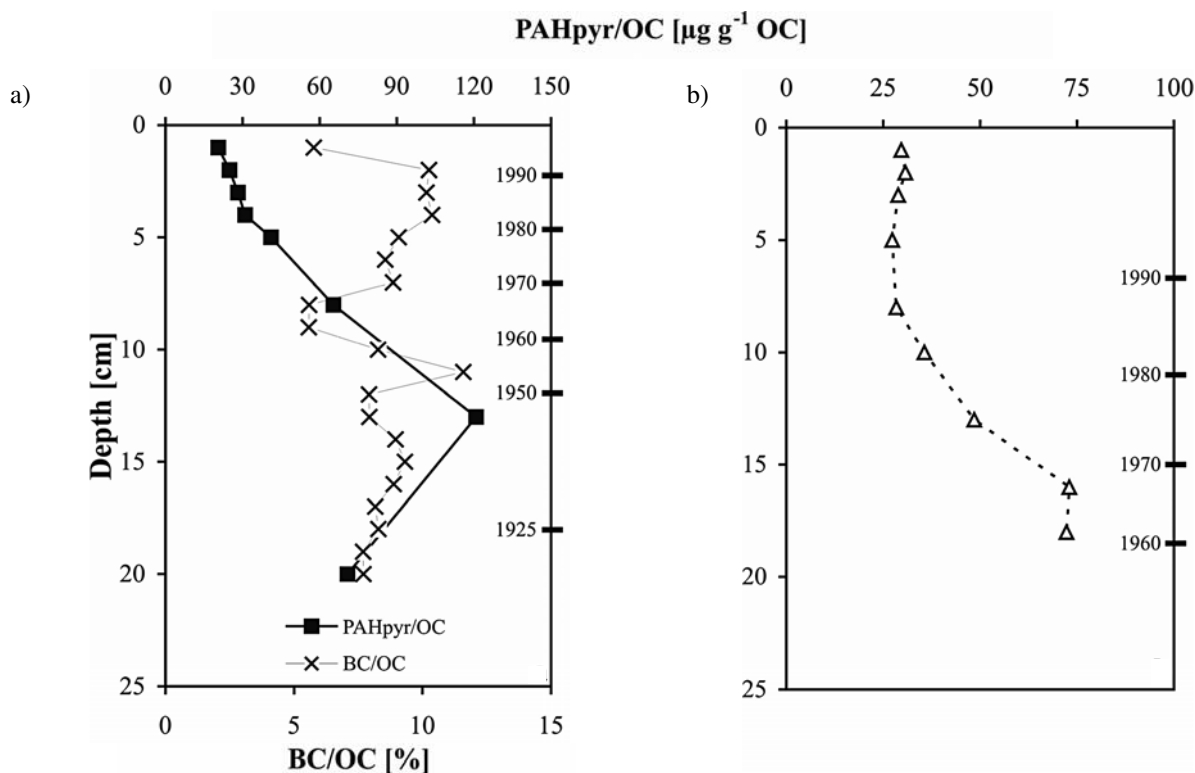

Figure 5: Depth profiles of the total pyrolytic PAH (PAH_{pyr}) and black carbon (BC) (data from Muri et al.[16]) concentrations normalized to organic carbon (OC) content in (a) the western basin and (b) Zaka Bay sediments. PAH_{pyr}/OC and BC/OC are from two different cores collected in the western basin (see text in 4.2) but have been plotted against the same age scale.

tion of 1430 m, showed a better resolved peak in the 1960s – 1970s, with maximum concentrations of ~75 µg PAH$_{pyr}$ g^{-1} OC.[6]

A comparison of Lake Bled PAH concentrations and PAH accumulation rates with other lakes (Table 1) shows that Lake Bled sediments are moderately contaminated with PAH. Lake Bled PAH concentrations and fluxes are in the lower range of urban lakes[5,17,18,19] but considerably higher than for remote sites.[4,20,21,22] Surface sediments in nearby Lake Planina were about 4-fold lower in PAH$_{pyr}$/OC than in the western basin of Lake Bled. A present-day flux of 225 µg m^{-2} yr^{-1} for PAH$_{pyr}$ flux in Lake Planina[20] was approximately 3-fold lower than Lake Bled. Because Lake Planina is a remote and protected mountain lake in a national park, the primary source of pollutants can only be via atmospheric transport.[6] On the other hand, Lake Bled receives both long range atmospheric pollution, as well as local pollution due to its urban watershed, probably mostly via storm water runoff.[5] Comparing PAH$_{pyr}$/OC and fluxes to Lakes Bled and Planina, we estimate that up to one-third of the total PAH input in Lake Bled derives from long range transport through the atmosphere, whereas the remaining two-thirds might originate from various local sources.

Table 1: Surface sediment PAH concentrations and fluxes in Lake Bled, other urban and remote lakes.

Location	PAH[a] [ng g^{-1}]	PAH[a] [µg m^{-2} yr^{-1}]	PAH[a]/OC [µg g^{-1} OC]	Ref.
Urban lakes				
the western basin (Lake Bled)	1100	650	21	
Zaka Bay (Lake Bled)	1600	1800	30	
Lake Michigan, US	1300–4100	150–1600	21–84	17
Lake Erie, US	120–5100	nd	nd	18
Lake Washington, US	500	350	11	5
Taihu Lake, China	1200–4800	nd	nd	19
Alpine and remote lakes				
Lake Planina, Slovenia	750	225	5	20
Central European alpine lakes	480–850	40–150	13–17	21
Loch Coire nan Arr, UK	630	nd	nd	4
Lake Suwa, Japan	240	460	nd	22

[a] PAH$_{pyr}$ concentration, nd: not determined

PAH are often associated with another high temperature pyrolysis product, black carbon (BC),[9,23,24] making BC a good carrier for sorbed PAH in aquatic environments. We did not measure BC in Lake Bled as part of the current project, but it was measured in another age-dated core collected in the western basin in 1998 (Fig. 4 of Muri et al.[16]). BC concentrations (data not shown) amounted to 3 mg BC g^{-1} dw at the sediment surface, increased somewhat to ~5 mg g^{-1} dw at 2 cm (deposited ~1990), and

eventually decreased to ~2 mg g^{-1} dw at the bottom of the core (25 cm; deposited about 1900). Because PAH and BC were measured in different cores, we normalized BC concentration to OC (Fig. 5a) to facilitate between-core comparison and plotted PAH$_{pyr}$/OC and BC/OC ratios against the same time scale to compare temporal trends. Assuming that the two cores are in fact comparable sedimentologically, we found that PAH and BC profiles were not entirely parallel, i.e. sediments deposited since about 1960 contained progressively decreasing PAH$_{pyr}$/OC concentrations up-core, whereas BC/OC were high over the same period, and in fact were roughly the same even at the bottom of the core. A decoupling of PAH from BC is not easy to explain, if the two phases are so closely associated physically,[9] and since normalization to OC should minimize differences between the two cores. However, similar PAH$_{pyr}$/OC and BC/OC depth profiles and an apparent decoupling of PAH from BC in the upper sediments were also observed in Lake Planina.[6] Given that BC measurements are subject to operational constraints,[23,25,26] wherein BC concentrations measured in complex organic and mineral matrices may actually be over-estimated, it might be that our measured BC concentrations in the OC-rich upper sediments of the western basin[16] and Lake Planina[16] are also unrealistically high. Further work would thus be needed to clarify the relationships between PAH and BC in recent lake sediments in Slovenia.

5. Conclusions

PAH were determined in urban Lake Bled (NW Slovenia), i.e. sediment cores from the western basin and Zaka Bay. Higher total PAH concentrations were observed in the Zaka Bay core. Based on partitioning of PAH into groups by molecular weight (number of rings) and calculating several PAH ratios, we conclude that most PAH in Lake Bled sediments are pyrogenic, probably of coal combustion origin. Furthermore, quite uniform compositions and depth distributions for pyrolytic PAH were observed in both cores, suggesting that pyrogenic inputs dominated over the time spans represented by the cores. Depth distributions of PAH were used to estimate the pollution history of the area. Lake Bled is moderately contaminated with PAH compared to other urban lakes. The highest PAH inputs were observed in the mid 20th Century, while contemporary inputs decreased markedly. Nevertheless, contemporary PAH inputs into Lake Bled are still 3–4 fold higher than in nearby but remote alpine Lake Planina, pointing to elevated PAH contamination in the urban watershed compared to an alpine national park. We furthermore estimate that up to one-third of the total PAH input in Lake Bled derives from long range transport of pyrolytic PAH through the atmosphere, whereas the remaining two-thirds might originate from various local sources.

6. Acknowledgements

7. References

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Povzetek

Določili smo policiklične aromatske ogljikovodike (PAH) v dveh jedrih sedimenta iz urbanega Blejskega jezera (SZ Slovenija). V površinskem sedimentu iz globlje zahodne kotanje je celotna koncentracija PAH znašala 1150 ng g^{-1} suhe teže, medtem ko je bila koncentracija PAH v zalivu Zaka, ki je plitvejši in bližje obali, 1900 ng g^{-1} suhe teže. PAH, ki vsebujejo štiri do šest obročev, so bili najbolj pogosti, kar bi pomenilo, da je večina PAH v Blejskem jezeru pirogenega izvora. Verjetno izvirajo iz izgorevanja premoga, kar lahko sklepamo na osnovi več PAH razmerij. Sestava pirogenih PAH po globini je bila v obeh jedrih konstantna. Najvišje koncentracije PAH v sedimentu iz Blejskega jezera so bile v predelu sedimenta, ki izvira iz sredine 20. stoletja (okrog 1945), in sicer 120 μg g^{-1} organskega ogljika (OC), medtem ko trenutne koncentracije znašajo 21 μg g^{-1} OC v zahodni kotanji in 30 μg g^{-1} OC v zalivu Zaka. Na osnovi koncentracij PAH in hitrosti sedimentacije ocenjujemo, da znašajo snovni tokovi PAH 630 μg m^{-2} leto^{-1} v zahodni kotanji in 1800 μg m^{-2} leto^{-1} v zalivu Zaka. Trenutni snovni tokovi PAH v Blejsko jezero so tako še vedno 3–4 krat višji kot v bližnjem, odmaknjenem alpskem Jezeru na Planini pri Jezeru, kar potrjuje povišano onesnaževanje s PAH v urbanem okolju.