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Assessment of Polycyclic Aromatic Hydrocarbons in Urban Water Bodies: A Study of Rivers and Lakes in Dhaka, Bangladesh

Abida Sultana*, Md. Mazharul Islam, Mohammad Shoeb, Md. Iqbal Rouf Mamun and Nilufar Nahar

Department of Chemistry, University of Dhaka, Dhaka-1000, Bangladesh

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Abstract

Polycyclic aromatic hydrocarbons (PAHs) pose significant environmental and health risks due to their toxic properties, making their assessment in urban water bodies crucial. This study aims to evaluate the presence of three notable PAHs—anthracene, fluoranthene, and benzo[a]pyrene—in the surface water of three rivers (Buriganga, Meghna, and Turag) and two lakes (Hatirjheel and Gulshan) in Dhaka, Bangladesh. High-performance liquid chromatography with fluorescence detector (HPLC-FD) was employed and validated for PAH determination, using solid phase extraction (SPE) with preconditioned C-18 SPE cartridge for sample extraction. Calibration showed excellent linearity with correlation coefficient (R^2) ≥ 0.999. The limits of detection (LODs) were 200 ng/L for anthracene and 0.63 ng/L for both fluoranthene and benzo[a]pyrene, with corresponding limits of quantification (LOQs) of 660 ng/L and 2.08 ng/L, respectively. Percent recovery was 91.38% for anthracene, 85.49% for fluoranthene, and 95.72% for benzo[a]pyrene, with relative standard deviations (RSD) of 5.27, 17.55 and 2.84%, respectively. Most water samples had PAH levels below detection limits (bdl) such as anthracene (bdl-1789.57 ng/L), fluoranthene (bdl-1309.23 ng/L), and benzo[a]pyrene (bdl-25.17 ng/L), and the detected concentrations were significantly lower than WHO and USEPA guideline values. This indicates a relatively low level of PAHs contamination in the studied water bodies

Keywords: PAHs, Solid phase extraction, HPLC-FD, Surface water, Environmental monitoring, Toxic pollutants.

I. Introduction

Concerns about the aquatic environment have always been extremely significant for the entire world as pollution threatens numerous types of micro and macro organisms found in rivers and lakes. Polluted wastewater, effluent discharge, storm water runoff, and air deposition all contribute to organic and inorganic contaminants entering rivers and lakes[1,2]. Toxic pollutants may accumulate in aquatic bodies such as fish and mussels, and since they are consumed, they can pose a considerable potential danger to people[3]. PAHs are hazardous pollutant that can endanger the human health and trigger harmful effects to aquatic life and ecological systems[4]. PAHs are a class of environmental pollutants reported as persistence, tenacious, hazardous, genotoxic, and oncogenic[5]. There are a wide range of primarily natural sources of PAHs in the environment such as forest fires, volcanic, and bacteria decay of organic materials. The anthropogenic sources are categorized as industrial, automobile, agricultural, natural, and domestic[6,7]. They are widespread pollutants and major components of air pollution that are formed by the incomplete burning of organic substances including tobacco products, biomass, wooden materials, and petroleum-based materials[8].

In the environment, there are numerous PAHs and 16 of them has identified as priority pollutants by the United States Environmental Protection Agency (EPA). Anthracene, fluoranthene, and benzo(a)pyrene are included in this list[9,10]. Anthracene, derived from coal tar, is pivotal in producing alizarin and other dyes, with its primary conversion into anthroquinone as a precursor[11]. Anthracene often enters the body by consuming contaminated food or water. Concerns about river and lake pollution include living things degradation, loss of fish and animal habitat, and health risks associated with the ingestion of river carp[12,13]. Anthracene, once in body, might target fat tissues or organs such as the kidneys and liver[14]. Fluoranthene, the most prevalent and prolific pyrogenic PAH has a poor water solubility of 0.26 mgL^{-1}, which significantly reduces its bioavailability[15,16]. Generated by activities like wood burning or gasoline use, particulate matter adheres to airborne particles, posing risks when inhaled or deposited into ecosystems.[17]. Benzo[a]pyrene is produced by insufficient burning of organic materials at temperatures ranging from 300 °C to 600 °C and is found in a variety of products ranging from coal tar to many foods, particularly smoked and grilled meats, and tobacco burning as in cigarettes smoking[18,19].

Dhaka, Bangladesh's capital has one of the greatest urban growth rates among developing countries[20]. The deteriorating water environment is another adverse consequence of increased urbanization[21]. Alongside untreated industrial and household waste, the presence of burnt motor oil, lubricants, and dyeing chemicals, which could potentially contain PAHs, significantly adds to the pollution burden in these water bodies. As a result, it is believed that water utilized for human intake, industrial uses, agricultural irrigation, and fish production is heavily

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*Author for correspondence. e-mail: abida.chem@gmail.com

polluted by these toxic substances[22]. To safeguard the wellness of humans and keep up the healthy ecological state of the aquatic environment, a better knowledge of the spatial distribution and hazard level of PAHs in aquatic environments surrounding the Dhaka city is required. As a result, extensive surveillance and assessment of PAHs in river and lake water are instinctively necessary in this megacity[23,24]. The objective of this research is to assess the levels of PAHs, specifically anthracene, fluoranthene, and benzo[a]pyrene, in the surface waters of three rivers (Buriganga, Meghna, and Turag) and two lakes (Hatirjheel and Gulshan) in Dhaka, Bangladesh. This study employs high-performance liquid chromatography with fluorescence detection (HPLC-FD) and solid phase extraction (SPE) using preconditioned C-18 SPE cartridges to validate the method and determine the concentration of these PAHs in the collected water samples.

II. Experimental

Sampling Area

The samples were collected from five different sources of water in Dhaka city and its close vicinity (Fig. 1). Hatirjheel, centrally located in Dhaka, is surrounded by residential areas and serves as a major travel route for local neighborhoods[25]. However, the water quality of nearby Gulshan Lake has critically deteriorated due to severe pollution, threatening local biodiversity[26]. Hatirjheel itself is a 3.8 km long and 2.5 m deep area facing environmental challenges[27]. The Meghna River, another major water body, suffers from extensive pollution, particularly around Meghna Ghat, due to industrial activities from shipyards, cement factories, and chemical companies[28,29]. Similarly, the Buriganga River is heavily polluted with waste from mills, factories, households, and healthcare facilities, compounded by Dhaka's daily solid waste disposal into the river[30,31]. The Turag River is also contaminated by effluents from numerous commercial and industrial sectors, which discharge untreated waste into the water. These pollution issues collectively pose significant environmental and health risks in Dhaka[32].

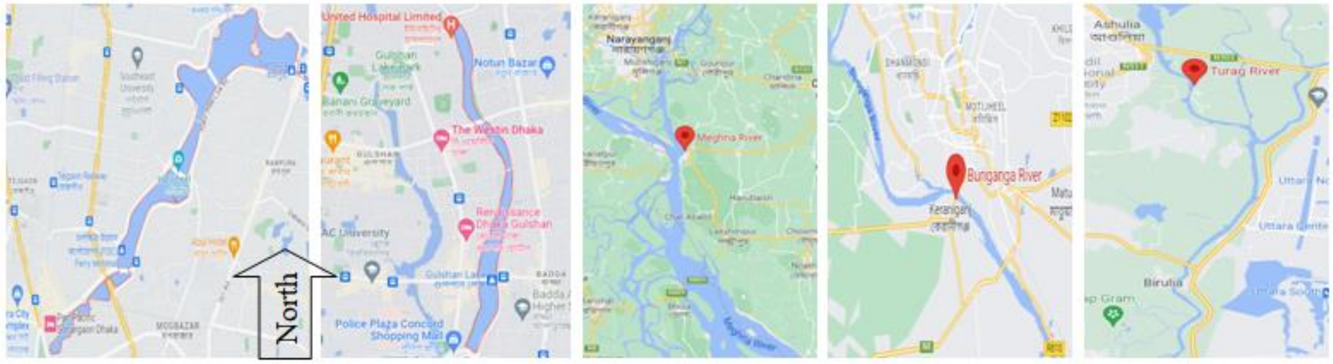

Fig. 1. Sampling area (left to right)- Hatirjheel, Gulshanlake, Meghna, Buriganga and Turag river.

Sample Collection

A total of 46 water samples with three replications were collected from Hatirjheel lake (H-1 to H-10), Gulshan lake (G-1 to G-10), Meghna river (M-1 to M-8), Buriganga river (B-1 to B-8), and Turag river (T-1 to T-10) on January (Fig. 1). Sampling stations were at least 0.5 km from each other in lakes and 1 km in river. Samples were collected 20-25 cm depth from surface of the water in a pre-cleaned 1 liter plastic bottle, transported to the laboratory and stored at 4 °C until analysis.

Solid-Phase Extraction of PAHs

For the purpose of extraction of water samples, C-18 cartridges were used. The cartridges were conditioned before the extraction procedure by successively passing 10 mL of each deionized water (Milli-Q system), methanol (Merck, KGaA, 64271, Darmstadt, Germany), and deionized water, respectively through the cartridges. 500 mL of water sample was allowed to pass through a C-18 cartridge for about two hours. Flow rate was maintained to be about 4 mLmin^{-1} using a sartorius vacuum pump. Then about 30 mL acetonitrile (HPLC grade from E. Merck, Germany) was passed through the cartridge for about 30 minutes. Flow rate was maintained to be 1 mLmin^{-1} and the eluate was collected in a sphere shape flask. The content of the flask was evaporated to complete dryness in rotary vacuum evaporator. Finally the dried mass was reconstituted in 1 mL HPLC grade acetonitrile and transferred to a vial. The sample extract was analyzed using HPLC-Fluorescence Detector. Retention time and corresponding peak area was recorded. The amount of anthracene, benzo[a]pyrene, and fluoranthene present in sample was calculated using standard calibration curve.

HPLC-FD Analysis

Instruments involved in the analytical process included an HPLC with fluorescence detector (Shimadzu CTO 10AS vp), a C-18(2) 100A 250×4.5 mm column, an analytical balance (104, Mettler Toledo, US), an oven (G-1020, Salvis), a rotary vacuum evaporator (Heidolph, Germany), a vortex machine (Kebo LabReax-2000), and minor equipment including a Sartorius vacuum pump and Alltech Backmaster (Brazil). All standard PAHs (purity ~ 99.9%) were purchased from SUPELCO, USA. The standards were stored in a refrigerator maintaining temperature -20 °C. Primary standard solution of 100 ppm of each anthracene, fluoranthene and benzo[a]pyrene were prepared by dissolving them separately in acetonitrile. The working standard solutions were prepared by serial dilution of primary standard solution with solvent. The prepared working standard solutions were injected in order of increasing concentration. Retention time and corresponding peak area was recorded. The calibration curves were obtained by plotting the peak area for each standard against the concentration. Some chromatograms of standard are shown in Fig. 2. Analytical Conditions of HPLC-FD were as follows: Pump: Low pressure, Column: C-18 (2), (250x4.6 mm), Particle size: 5µm, Flow rate: 1mL/min, Column-oven temperature: 30 °C, Injection volume: 20µL, Injection interval: 10 min, Mobile phase: HPLC grade water and Acetonitrile, Isocratic separation, Solvent ratio, Water-Acetonitrile: 5:95, Fluorescence; Excitation wavelength: 340 nm and emission wavelength: 425 nm.

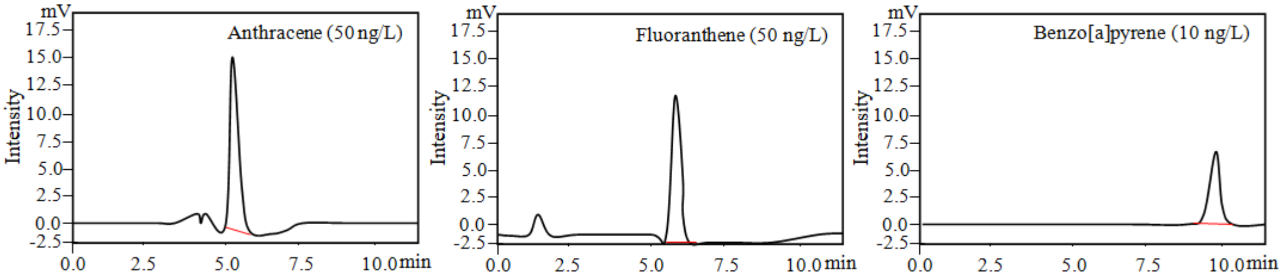

Fig. 2. Chromatogram of standard anthracene (50 ng/L), fluoranthene (50 ng/L), and benzo[a]pyrene (10 ng/L)

Statistical analysis

In this study, the standard deviation (S) and relative standard deviation (RSD) were calculated for the assessment of PAHs in urban water bodies. Each water sample and recovery experiment was analyzed in triplicate. Microsoft Excel was utilized for these calculations, applying standard mathematical formulas to determine the precision and reproducibility of the results. The calculated RSD values provided insight into the consistency of the analytical method, ensuring the reliability of the high-performance liquid chromatography with fluorescence detection (HPLC-FD) and solid phase extraction (SPE) techniques employed in this research. The following statistical equations are used for calculating S (Eq. 1) and RSD (Eq.2).

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}} \text{ ---------------------(Eq. 1)}$$

$$\text{RSD (\%)} = \frac{\text{S}}{\text{Mean}} \times 100 \text{ ------------(Eq. 2)}$$

Where, x = Each value of the data set, x̄ = Mean of all the values in the data set, and n = number of vales in the data set.

Quality control and quality assurance

The method was validated in terms of calibration, linearity, identification, selectivity, precision, accuracy (recovery), specificity, LOD, and LOQ[33,34]. LOD and LOQ were determined by injecting diluted standard solutions of PAHs in HPLC-FD. For LOD, the peak height of the corresponding compounds were considered three times higher than the base-line noise and for LOQ, the peak height was considered to be ten times higher than the base-line noise[35]. The recovery (accuracy) experiment was carried by using 500 mL deionized water[36]. The spiking level was 20 ngL^{-1} for anthracene, fluoranthene, and benzo[a]pyrene, respectively. Five replicate recoveries were done for each standard. Recovery experiment was carried out using a C-18 cartridge as described in SPE of PAHs from water. The sample extract was analyzed by HPLC-FD following the same analytical conditions as HPLC-FD. Following equation (Eq.3) is used for the calculation of recovery percentage:

$$\text{Recovery (\%)} = \frac{\text{Amount found}}{\text{Added amount}} \times 100 \text{ ------------(Eq. 3)}$$

Selectivity (or specificity) was assessed by analyzing standard solutions of PAHs, blank solutions, and by checking their retention times. To identify any undesired substances potentially affecting the analytes, chromatograms of both standard and blank samples were compared, revealing no interference peaks at the retention times corresponding to anthracene, benzo[a]pyrene, and fluoranthene. Linearity was assessed by generating calibration curves using the standard compounds[37]. Calibration curves of standard anthracene, benzo[a]pyrene, and fluoranthene were constructed as peak area *vs* concentration. The linearities were excellent with correlation coefficients of $R^2 \geq 0.999$ for anthracene, fluoranthene and benzo[a]pyrene.

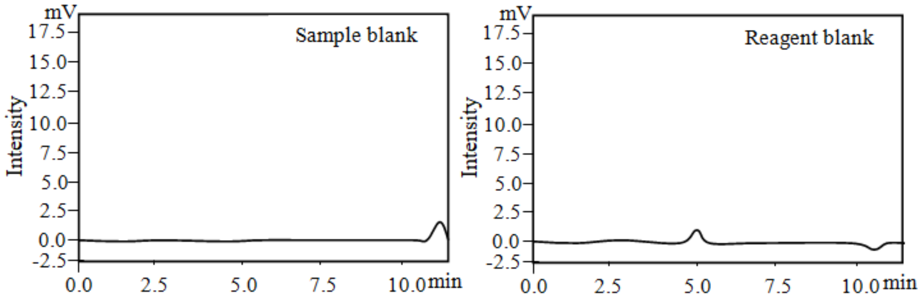

Fig. 3. Chromatogram of Blank Sample (left) and reagent Blank (right)

III. Results and Discussion

A total of 46 water samples from Hatirjheel lake (n=10), Gulshan lake (n=10), Meghna river (Narayangonj) (n=8), Burigangariver (Dhaka) (n=8), and Tungi river (Gajipur) (n=10) were collected to analyze in this study. The linearity was excellent with correlation coefficients of $R^2 \geq 0.999$ for anthracene, fluoranthene, and benzo[a]pyrene. The amounts of targeted PAHs in water samples were determined via the calibration curve method. The extraction efficiency of the analytical procedure was evaluated *via* recovery experiments using distilled and deionised water as control sample. The mean recovery rates for anthracene, fluoranthene, and benzo[a]pyrene were 91.38, 85.49, and 95.72%, respectively. Furthermore, RSD for anthracene, fluoranthene, and benzo[a]pyrene were 5.27, 17.55, and 2.84%, respectively (Table 1).

Table 1. Method Validation Parameters of targeted PAHs

PAHs	Regression line	R^2	LOD (ngL^{-1})	LOQ (ngL^{-1})	Recovery±SD (%)	RSD (%)
Anthracene	y= 3.268x + 1953	0.999	200	660	91.38±4.82	5.27
Fluoranthene	y= 11.05x + 839.6	0.999	0.63	2.08	85.49±2.43	17.55
Benzo[a]pyrene	y= 389.8x + 970.5	0.999	0.63	2.08	95.72±16.80	2.84

Water samples collected from three different rivers and lake were extracted by SPE technique and analyzed by HPLC-FD. Some chromatograms of collected samples are shown in Fig. 4, in which the presences of target PAHs are confirmed.

The amounts of anthracene, fluoranthene and benzo[a]pyrene in different water samples from all the sources are shown in Table 2-6.

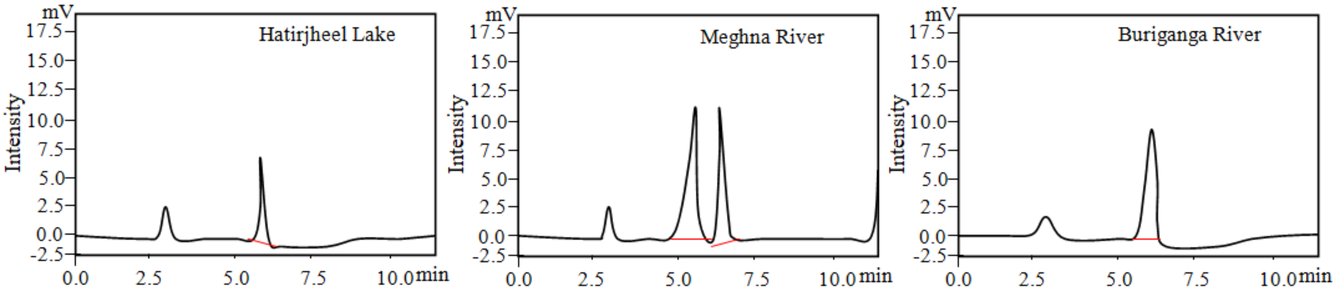

Fig. 4. Chromatogram of water sample of Hatirjheel lake (left), Meghna river (middle) and Burigangariver (right)

Table 2. PAHs (ngL^{-1}) in Water Samples of Meghna River

Sample ID	Anthracene		Fluoranthene		Benzo[a]pyrene	
	Average ± SD	RSD (%)	Average ± SD	RSD (%)	Average ± SD	RSD (%)
M-1	1789.57±22.43	1.25	10.16±0.88	8.66	bdl	-
M-2	bdl	-	bdl	-	bdl	-
M-3	bdl	-	bdl	-	bdl	-
M-4	823.96±42.59	5.16	230.26±37.54	16.30	bdl	-
M-5	bdl	-	1309.23±59.27	4.53	bdl	-
M-6	bdl	-	bdl	-	bdl	-
M-7	bdl	-	69.72±14.61	20.96	bdl	-
M-8	bdl	-	17.09±1.52	8.91	bdl	-

Note: RSD-Relative standard deviation

Table 3. PAHs (ngL^{-1}) in Water Samples of Buriganga River

Sample ID	Anthracene		Fluoranthene		Benzo[a]pyrene	
	Average±SD	RSD (%)	Average±SD	RSD (%)	Average±SD	RSD (%)
B-1	bdl	-	8.79±0.89	10.18	bdl	-
B-2	bdl	-	bdl	-	bdl	-
B-3	bdl	-	bdl	-	bdl	-
B-4	bdl	-	8.21±0.92	11.24	bdl	-
B-5	bdl	-	6.89±0.62	9.00	bdl	-
B-6	bdl	-	3.99±0.52	13.07	bdl	-
B-7	bdl	-	bdl	-	bdl	-
B-8	bdl	-	7.50±1.46	19.51	bdl	-

The results showed all three PAHs were present in varying amounts in the analyzed water samples. From the Table 2, it is showed that anthracene was found to be present in only two sampling points of the Meghna river as 1789.57 ngL^{-1} (M-1) and 823.96 ngL^{-1} (M-4) and below detection limit (bdl) in other six sampling points. Anthracene is also present as bdl in the entire sample collected from Burigangariver (Table 3), Turag river (Table 4), Hatirjheel lake (Table 5) and Gulshan lake (Table 6) except one sampling point (G-5) of as 2937.62 ngL^{-1}. The level of anthracene found in those samples are far below the guideline value (2000 μgL^{-1}) reported by world health organization (WHO)[38]. The elevated levels of anthracene in samples collected from the Meghna river and Gulshan lake water are attributed to industrial effluent discharge or vehicle emissions, which are subsequently washed into the river by rainfall. The presence of anthracene in varying concentrations at different sampling sites in bdl is likely the result of its volatility, dissolution, biological degradation, photooxidation, and rapid photolysis.

Table 4. PAHs (ngL^{-1}) in Water Samples (n=3) Collected from Turag River

Sample ID	**Anthracene**		**Fluoranthene**		**Benzo[a]pyrene**	
	Average±SD	RSD (%)	Average±SD	RSD (%)	Average±SD	RSD (%)
T-1	bdl	-	3.70±0.62	16.89	bdl	-
T-2	bdl	-	3.03±0.37	12.51	bdl	-
T-3	bdl	-	bdl	-	bdl	-
T-4	bdl	-	9.40±1.85	19.77	bdl	-
T-5	bdl	-	3.07±0.23	7.74	bdl	-
T-6	bdl	-	3.64±0.64	17.50	bdl	-
T-7	bdl	-	3.53±0.04	1.15	bdl	
T-8	bdl	-	3.37±0.07	2.00	bdl	-
T-9	bdl	-	4.18±0.16	3.83	bdl	-
T-10	bdl	-	5.36±0.58	10.89	bdl	-

Table 5. PAHs (ngL^{-1}) in Water Samples Collected from Hatirjheel Lake

Sample ID	Anthracene		Fluoranthene		Benzo[a]pyrene	
	Average ± SD	RSD (%)	Average ± SD	RSD (%)	Average ± SD	RSD (%)
H-1	bdl	-	59.29±6.86	11.57	25.17±0.74	2.96
H-2	bdl	-	1190.74±35.50	2.98	bdl	-
H-3	bdl	-	bdl	-	bdl	-
H-4	bdl	-	bdl	-	5.47±0.94	17.32
H-5	bdl	-	bdl	-	bdl	-
H-6	bdl	-	61.76±10.23	16.57	22.69±0.58	2.59
H-7	bdl	-	bdl	-	bdl	-
H-8	bdl	-	6.16±1.09	17.82	bdl	-
H-9	bdl	-	bdl	-	bdl	-
H-10	bdl	-	7.12±0.41	5.88	bdl	-

On the other hand, all the water samples collected from every source contained fluoranthene in varying amounts (bdl-1309.23 ngL^{-1}) (Table 2 to Table 6). For example, the amount of fluoranthene in water sample was bdl-1309.23, bdl-8.79, bdl-9.40, bdl-1190.74 and bdl-6.98 ngL^{-1} in Meghna river, Burigangariver, Turag river, Hatirjheel lake, and Gulshanlake, respectively. The trends of anthracene level was M-5>M-4>M-7>M-8>M-1>M-2∼M-3∼M-6(bdl) in Meghna river (Table 2); B-1>B-4>B-8>B-5>B-6>B-2∼B-3∼B-7(bdl) in Burigangariver (Table 3); T-4>T-10> T-9>T-1>T-6>T-7>T-8>T-5>T-2>T-3(bdl) in Turag river (Table 4); H-2>H-6>H-1>H-10>H-8>H-3∼H-4∼H-5∼H-7∼H-9(bdl) in Hatirjheel lake (Table 5) and G-1>G-4>G-9>G-6>G-8>G-10>G-2∼G-3∼G-5∼G-7(bdl) in Gulshanlake (Table 6). The level of fluoranthene found in those samples are far below the guideline value (300 μgL^{-1}) reported by world health organization (WHO)[38]. Similarly, a very carcinogenic PAH benzo[a]pyrene was found in bdl level in all water samples from Meghna river (Table 2) Burigangariver (Table 3), Turag river (Table 4) and Gulshanlake (Table 6) but found in only three sampling point such as H-1 (25.17 ngL^{-1}), H-4 (5.47 ngL^{-1}) and H-6 (22.69 ngL^{-1}) out of ten in Hatirjheel lake. The level of benzo[a]pyrene found in those samples are far below the guideline value (200 ngL^{-1}) reported by USEPA[39,40].

Table 6. PAHs (ngL^{-1}) in Water Samples Collected from Gulshan Lake

Sample ID	Anthracene		Fluoranthene		Benzo[a]pyrene	
	Average ± SD	RSD (%)	Average ± SD	RSD (%)	Average ± SD	RSD (%)
G-1	bdl	-	6.98±0.94	13.47	bdl	-
G-2	bdl	-	bdl	-	bdl	-
G-3	bdl	-	bdl	-	bdl	-
G-4	bdl	-	6.18±0.47	7.53	bdl	-
G-5	2937.62±8.20	7.09	bdl	-	bdl	-
G-6	bdl	-	5.10±0.56	11.02	bdl	-
G-7	bdl	-	bdl	-	bdl	-
G-8	bdl	-	4.73±0.16	3.37	bdl	-
G-9	bdl	-	5.81±0.23	4.05	bdl	-
G-10	bdl	-	4.36±0.05	1.26	bdl	-

The study conducted by Nahar et al. (2023) analyzed the concentration of PAHs in the Buriganga river water. The mean concentration anthracene, fluoranthene, and benzo[a]pyrene were 590.9, 1855.7 and 21.7 ngL^{-1}, respectively, based on the analysis of 15 water samples[41]. Mandal et al. (2015) conducted an analysis on surface water samples collected from lakes and ponds in Dhaka city, with a sample size of ten each. Their study revealed that anthracene was present in four tap water samples at concentrations ranging from 37000 to 54000 ng/L[42]. Habibullah-Al-Mamun et al. (2018) collected a total of 28 water samples from four coastal sites along the southeast and southwest regions of the Bay of Bengal coast in Bangladesh, encompassing fourteen distinct sampling locations. The mean concentration anthracene, fluoranthene, and benzo[a]pyrene were 179.8, 225.9 and 19.9 ngL^{-1}, respectively[43].

The reason of the presence of anthracene, benzo[a]pyrene, and fluoranthene in the river water might be anthropogenic for their industrial discharge, urban runoff, oil spil, combustion process and atmospheric deposition[44]. A numbers of ship building and repair yards are located in the bank of the river Burigangaand Meghna. The areas nearby these rivers are also recognized as highly industrialized with small chemical and pharmaceutical industries, tanneries, paints and dye industries are situated around. Anthracene, fluoranthene, and benzo[a]pyrene are prevalent in the environment due to various factors such as urban runoff, oil spills, coal burning, atmospheric deposition, untreated industrial and domestic waste discharge, as well as effluent discharge from Dhaka city. Microorganisms like bacteria, fungi, and algae also contribute to their presence.

In the rivers Meghna and Buriganga, launch terminals serve as points for shipment and loading-unloading activities, often leading to the release of engine oil. There are also trade places for burnt oil along the riverbanks, where oil is refined and sold back to the community. Additionally, engine boats contribute to oil pollution in the water bodies. Coal tars, containing over 1000 compounds including at least 30 PAHs, further contribute to the complexity of pollution. In addition to that, launches, ships, ferry etc. for inland navigation use coal tar to prevent corrosive damages. Leaching or abrasion of this coal tar may be other sources for the contamination of river water by anthracene, benzo[a]pyrene and fluoranthene. Brick kilns represent another potential origin of PAHs found in the Burigangaand Meghna rivers, with approximately 300 of these kilns discharging their waste into these waterways[45]. During sampling from Turag, and Buriganga river, effluents coming from plastic factories, machineries industries, garments factories, and leather crafts making industries to the river was evidenced. It was not possible to know whether these effluents were treated through effluent treatment plant (ETP) or not before they were released. If not, these could be the potential sources of PAHs (in the present case, fluoranthene) in the Turag river and Buriganga river.

Hatirjheel lake, located centrally in the capital city of Bangladesh, Dhaka, is a significant expanse. Its proximity to the Tejgaon industrial area results in the disposal of various forms of industrial waste into the lake. Unfortunately, a huge land beside the lake area is being used for living purpose of slum people coming from the rural area of the country. These people along with some original residents of Hatirjheel lake dumping their household wastes directly to the lake. Drains and sewerage pipe dumping waste in the Hatirjheel lake polluting the surface water and the environment. These practice including wastes, petroleum products, dust of roads etc. might be the possible source of fluoranthene and benzo[a]pyrene in the Hatirjheel lake water. Gulshan lake is a confined water body with a length of 0.87 km located in a highly populated residential area of Dhaka city. Unfortunately, a huge land beside the lake area is being used for living purpose of slum people coming from the rural area of the country. Residents, including newcomers and locals, directly dispose of household waste into the lake, while the dumping of waste from drains and sewerage pipes into Gulshan lake has been flagged as a significant pollution issue by DWASA[46]. These practice including industrial wastes, petroleum products, dust of roads etc. might be the possible source of anthracene, fluoranthene and benzo[a]pyrene in the Gulshan lake water. In the research on PAHs in Urban Rivers and Lakes in Dhaka, Bangladesh, only a very small number of samples showed the presence of PAHs, with most concentrations falling below standard guideline values. Consequently, human health risk assessments, health hazard evaluations, and ecological risk factors were not calculated, as the detected levels of PAHs were deemed insufficient to warrant such analyses. Mitigating PAHs) in water is challenging, but heterogeneous photocatalysis using semiconductor metal oxides (e.g., TiO_2 and ZnO) and noble metal-doped graphene composites offers an efficient and eco-friendly solution[47]. Monitoring PAH levels during drinking water treatment processes showed that chemical treatments with $KMnO_4$, $FeCl_3$, and NaClO can achieve over 90% removal efficiency for certain PAHs. Gas chromatography-mass spectrometry analysis confirmed the highest removal rates for benzo(a)anthracene, benzo(a)pyrene, and dibenzo(a,h) anthracene[48].

IV. Conclusion

The study focuses on PAHs, globally recognized as critical priority pollutants. Using a cost-effective Solid Phase Extraction (SPE) method without derivative processes, the research assesses three targeted PAHs in water samples from Dhaka's rivers and lakes. Results indicate significant levels of fluoranthene in Hatirjheel Lake, Meghna, Buriganga, and Turag rivers; anthracene in Meghna River; and benzo[a]pyrene in Hatirjheel Lake. Despite relatively low LOD and LOQ, HPLC-FD proves suitable for routine PAH analysis in water. The study highlights acute anthropogenic sources as contributors to PAH contamination, emphasizing vehicular emissions and urban combustion activities. Recommendations include implementing safety measures in industries and households and addressing vehicle emissions and fuel burning practices to achieve a sustainable environment. Overall, the method successfully determines PAH levels in Dhaka's water bodies, underlining the need for pollution mitigation efforts.

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