Research Article

Determination of Polycyclic Aromatic Hydrocarbons (PAHs) and their Sources in Ganga River Water, Uttar Pradesh, India

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Submission Date: 14-06-2023; Revision Date: 17-08-2023; Accepted Date: 15-09-2023.

ABSTRACT

Aims: To evaluate the US EPA listed sixteen carcinogenic and mutagenic Polycyclic aromatic hydrocarbons (PAHs) contamination in Ganga River water which supports the livelihood of more than 400 million people in many ways such as drinking, bathing, industrial, agricultural, ritualistic and other household activities. **Materials and Methods:** The Ganga River water was collected from three cities namely Jajmau (Kanpur), Katari Bhalepur (Fatehpur) and Kursinda Kachar. Sample preparation was carried out following APHA AWWA 610 method and analyzed by High Performance Liquid Chromatography (HPLC) equipped with a UV detector. **Results:** In the present study, eight PAHs with their mean concentration were as Acy (4.897±5.3709) > Ace (0.7081±0.8232) > Fln (0.6239±0.3327) > Phe (0.2443±0.226) > Flu (0.1555±0.0737) > Chy (0.0232±0.0082) > Ant (0.01166±0.00324) > BaA (0.0096±0.0046) in Jajmau (Kanpur) while eleven PAHs were orderly as Acy (0.9456±0.2108) > Ace (0.3775±0.0546) > Phe (0.1503±0.0997) > Flu (0.1202±0.0170) > BaA (0.0815±0.0096) > BahA (0.0559±0.0014) > Chy (0.0557±0.039) > Fln (0.0446±0.0096) > BbF (0.0221±0.0075) > BkF (0.012±0.0022) > BaP (0.0098±0.00176 in Katari Bhalepur (Fatehpur). At Kaushambi Acy (0.4135±0.1575) > Ace (0.2177±0.0864) > Flu (0.15873±0.0456) > Fln (0.1136±0.1008) > BahA (0.099±0.0587) > BghiP (0.0916±0.0496) > BkF (0.0787±0.0449) > Phe (0.0747±0.01310) > IP (0.0467±0.0162) > BaA (0.0368±0.0284) > Chy (0.0333±0.0204) > BaP (0.0283±0.01723) > BbF (0.028±0.0120) > Ant (0.0027±0.00015) was detected. **Conclusion:** It was determined that Ganga River water at all study stations was contaminated by PAHs. The total PAHs measured in Ganga River water at all three cities were above the recommended safe limits, and also noticed that Ganga River water is contaminated by LMW PAHs at Kanpur while Fatehpur and Kaushambi were contaminated by both LMW and HMW PAHs which are more toxic over LMW PAHs.

Keywords: HPLC, Ganga River, PAHs, UV detector.

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INTRODUCTION

River Ganga is the longest river in India, flowing through different geographical regions and climatic zones. It is one of the largest river basins in India, with a total length of 2525 km.[1] It originates from the Gaumukh ice cave of the Gangotri Glacier system, after traversing the plain of five states namely Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal, discharges into the Bay of Bengal. Uttar Pradesh is the 4th biggest province in its geographical view and the largest province in terms of population in India.[2] It has major industrial cities such as Kanpur, Allahabad, Varanasi, and Mirzapur which directly or indirectly dump their domestic, industrial and agricultural wastes into the river Ganga. Due to the increasing demand for pharmaceuticals, pesticides, household and personal care products, the chemical pollutants have risen tremendously in river Ganga, which may threaten humans and other inhabitants of the river. Chemical contamination like Polycyclic

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DOI: 10.5530/ajbls.2023.12.34

Aromatic Hydrocarbons (PAHs), Nonylphenols (NPs), Polychlorinated Biphenyls (PCBs), dioxins, Phthalates may cause severe health concerns including cancer.[2,3] Among them PAHs are the major concern due to their mutagenicity and carcinogenicity. They bear two to six fused aromatic rings. According to the number of rings, these are categorized as Low Molecular Weight (LMW) and high molecular weight (HMW) compounds. 2-3 rings PAHs are included in LMW while 4-6 rings PAHs are included in HMW compounds. Natural sources of PAHs are included such as forest fires, coal deposits, volcanic emissions, and natural oil seep while the anthropogenic sources are grouped into pyrogenic (combustion of fossil fuel) and petrogenic (crude oil and petroleum products).[4,5] These contaminants enter into aquatic bodies by surface runoff, atmospheric deposition and wastewater discharges. River Ganga is worshipped by Hindus and also called as 'Maa', supports the livelihood of more than 400 million people in many ways such as drinking, bathing, industrial, agricultural, ritualistic and other household activities.[6,7] PAHs can enter the human body by oral and dermal exposure as well as dietary intake of contaminated aquatic organisms. Therefore, it becomes imperative to analyse PAHs in Ganga River water. US EPA listed sixteen carcinogenic PAHs namely (Naphthalene (Nap), Acenaphthylene (Acy), Acenaphthene (Ace), Fluorene (Flu), Phenanthrene (Phe), Anthracene (Ant), Fluoranthene (Fln), Pyrene (Pyr), Benzo(a)anthracene (BaA), Chrycene (Chy), Benzo(b)fluoranthene (BbF), Benzo(k)fluoranthene (BkF), Benzo(a)pyrene (BaP), Dibenzo(a.h)anthracene (BahA), Benzo(ghi)perylene (BghiP), and Indeno(1,2,3-cd)pyrene (IP) were analyzed in Ganga river water. Three sampling stations were selected based on socio-economic activities taking place which include agricultural, domestic, industrial operations and tourism activities Figure 1.

MATERIALS AND METHODS

Study Area and sample collection

The study area of present investigation was approximately 183 km at the Ganga River basin from Kanpur to Kaushambhi. The sampling sites were Jajmau (Kanpur, Latitude 26.434653° and Longitude 80.408475°), Katari Bhalepur (Fatehpur, Latitude (26.117338° and Longitude 80.661105°), and Kursinda Kachar (Kaushambhi, Latitude 25.70601° and Longitude 81.367768°). Kanpur is known as industrial hub having approximately 200 large and small industries, 18 drains that carrying domestic and industrial wastes, poured directly into river Ganga.[8] The river Pandu receive domestic wastes from villages/towns (Kaindepur, Sultanpur, Matinpur, Pure Dayal, Saurajpur, Kotla, Khalispur, Baghauli, Lahangi Aht) located at Fatehpur.[9] and these effluents ultimately dump into river Ganga at Katari Bhalepur (Fatehpur) i.e., meeting point of Pandu River to the Ganga. Kursinda Kachar (Kaushambi) is famous for its tourism and ritual activities. There are many famous temples such as Sheetala mata, Durga Devi, Kamasin Devi and Jain temple. Ashoka Pillar was built in 232 BC, the main attractions for archaeologists. Most of the land covered by agricultural and rural areas. Kursinda Kachar is the spot of present study, receive agricultural as well as ritual wastes. Triplicate water sample were collected on 28-2-2022, below 30 cm of the surface in the midstream of the river, in 1 litter plastic bottles which was wrapped by paper and immediately transferred into ice box to protect from sun light for PAHs analysis and 5 litre in plastic cane for physiological parameters. For PAHs analysis, the samples were instantly transferred in ice box and brought to the laboratory for further extraction and clean up while pH, Temperature (°C), Electrical Conductivity (EC), Total Dissolve Solid (TDS) were done at immediately at the spot.

Reagents

Sixteen mix PAHs external standard (2000 µg/mL) was purchased from Chem service Inc. Germany. Acetonitrile (CAS No. 75-05-8), n-hexane (CAS No. 110-54-3), Dichloromethane (CAS No. 75-09-2), were procured from Merk Life Sciences. Silica gel (CAS No. 112926-00-8) was bought from Sigma-Aldrich as high purity grade (7734), pore size 60Å, 70-230 mesh. $MnSo_4$, NaOH, NaI, H_2SO_4, $(C_6H_{10}O_5)_n$, $Na_2S_2O_3$, NH_4cl, Na_4oH, EDTA, EBT indicators were of analytical grade (98% purity). Ammonium, Nitrite, and Nitrate test were performed using their respective kit.

Figure 1: Sampling sites of present study.

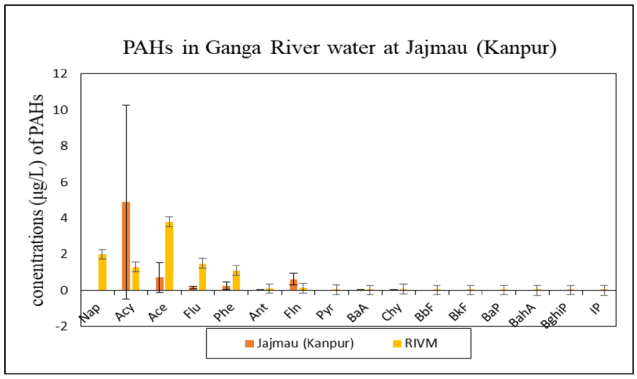
Extraction, Clean Up and Analyses of the Samples

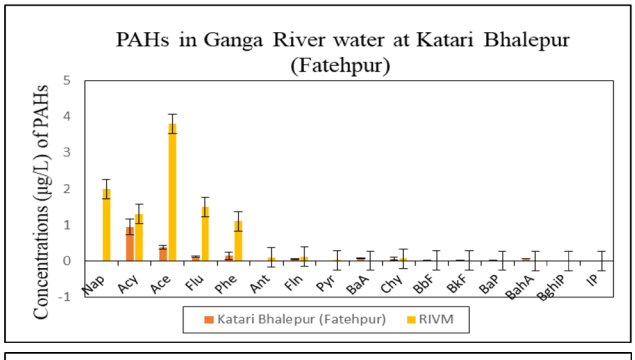
The extraction and cleanup of the sample were done within seven days of collection while the analysis of the sample was completed within forty days according to EPA method 610. The extraction and cleanup of the sample were carried out following the liquid-liquid extraction method APHA AWWA 610. The extraction procedure involved 1L water sample poured into 2L of the beaker, 80 mL of Dichloromethane (DCM), and the samples were shaken for 15 min. After shaking the sample, pour it into 2 L of a separatory funnel and hold it for 5 min for the phase separation (aqueous/nonaqueous). Furthermore, nonaqueous eluents were collected in another flask. The whole procedure repeated three times. The pooled extract was filter by Whatman 42 filter paper. For cleanup of the sample, we prepared the slurry of 10 g activated silica gel in 20 mL n-hexane and poured it into a 50 mL long and 10 mm Internal Diameter (ID) chromatographic glass column. The sample was demoisturized using 1-2 cm anhydrous sodium sulphate which was placed on the top of the column. The eluents were further concentrated using a rotatory evaporator, till the sample remained 0.5 µL and made up the sample 1 mL by adding 0.5 µL acetonitrile. 20 µL sample was injected into an Agilent 1220 Infinity HPLC, equipped with a UV detector (254 nm). Operating conditions were followed as APHA AWWA 2008: flow rate-0.9 mL/min, sample volume-20 µL, running time-45 min, column-ZORBAX Eclipse C18 (250 mm long x 5 µm ID), the ratio of mobile phase (distilled water/Acetonitrile) was as 60:40.

RESULTS

Pollution level of PAHs in Ganga River

The concentrations of the individual sixteen PAHs and their total numbers of all three sites are presented in Table 1. The concentrations of total PAHs ranged from 0.0027 to 4.897 µg/L. There are eight PAHs were determined in Jajmau (Kanpur), eleven at Katari Bhalepur (Fatehpur) and fourteen in Kurshinda Kachar (Kaushambi). Nap and Pyr were not detected at any sites while Acy, Ace, Flu, Phe, Fln, BaA and Chy were dominant at all three sites. Considerably, location-wise PAHs concentration (µg/L) followed the orderly Kaushambi > Fatehpur > Kanpur. The order of eight PAHs with their mean concentration, detected in Kanpur were as Acy (4.897±5.3709) > Ace (0.7081±0.8232) > Fln (0.6239±0.3327) > Phe (0.2443±0.226) > Flu (0.1555±0.0737) > Chy (0.0232±0.0082) > Ant (0.01166±0.00324) > BaA (0.0096±0.0046). Only LMW PAHs (3 – 4 rings) were detected in Jajmau (Kanpur) while both types (LMW and HMW) of PAHs were detected in Katari Bhalepur (Fatehpur) and Kurshinda Kachar (Kaushambi). The concentration of PAHs at Fatehpur orderly as Acy (0.9456±0.2108) > Ace (0.3775±0.0546) > Phe (0.1503±0.0997) > Flu (0.1202±0.0170) > BaA (0.0815±0.0096) > BahA (0.0559±0.0014) > Chy (0.0557±0.039) > Fln (0.0446±0.0096) > BbF (0.0221±0.0075) > BkF (0.012±0.0022) > BaP (0.0098±0.00176). At Kaushambi Acy (0.4135±0.1575) > Ace (0.2177±0.0864) > Flu (0.15873±0.0456) > Fln (0.1136±0.1008) > BahA (0.099±0.0587) > BghiP (0.0916±0.0496) > BkF (0.0787±0.0449) > Phe (0.0747±0.01310) > IP (0.0467±0.0162) > BaA (0.0368±0.0284) > Chy (0.0333±0.0204) > BaP (0.0283±0.01723) > BbF (0.028±0.0120) > Ant (0.0027±0.00015). BghiP and IP merely present in Kurshinda Kachar (Kaushambi). Ant was analyzed in two sampling stations (Jajmau and Kurshinda Kachar).





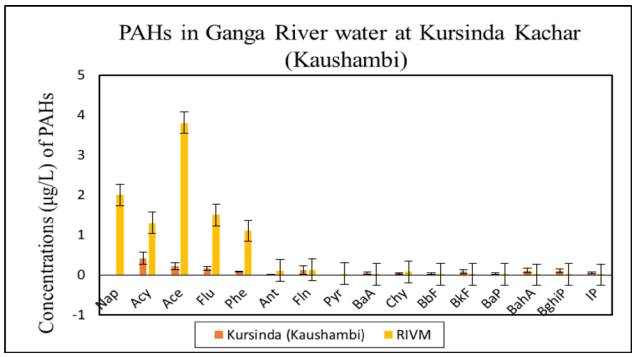


Table 1: PAHs concentration (µg/L) in Ganga River water at three sites.

Sl. No.	PAHs	Jajmau (Kanpur)	Katari Bhalepur (Fatehpur)	Kursinda Kachar (Kaushambi)	RIVM (2012)
1.	Nap	ND	ND	ND	2
2.	Acy	**4.897±5.3709**	0.9456±0.2108	0.4135±0.1575	1.3
3.	Ace	0.7081±0.8232	0.3775±0.0546	0.2177±0.0864	3.8
4.	Flu	0.1555±0.0737	0.1202±0.0170	0.15873±0.0456	1.5
5.	Phe	0.2443±0.226	0.1503±0.0997	0.0747±0.01310	1.1
6.	Ant	**0.01166±0.00324**	ND	0.0027±0.00015	0.10
7.	Fln	**0.6239±0.3327**	0.0446±0.0096	0.1136±0.1008	0.12
8.	Pyr	ND	ND	ND	0.023
9.	BaA	0.0096±0.0046	**0.0815±0.0096**	**0.0368±0.0284**	0.012
10.	Chy	0.0232±0.0082	0.0557±0.039	0.0333±0.0204	0.070
11.	BbF	ND	**0.0221±0.0075**	**0.028±0.0120**	0.017
12.	BkF	ND	0.012±0.0022	**0.0787±0.0449**	0.017
13.	BaP	ND	0.0098±0.00176	**0.0283±0.01723**	0.010
14.	BahA	ND	**0.0559±0.0014**	**0.099±0.0587**	0.0014
15.	BghiP	ND	ND	**0.0916±0.0496**	0.0082
16.	IP	ND	ND	**0.0467±0.0162**	0.0027
17.	∑PAHs	6.6732±6.8425	1.8752±0.4532	1.4233±0.6509	

ND = Not detected.

It was noticed that the concentrations of Acy, Ant and Fln were higher than the safe limit recommended by RIVM 2012[11] at Jajmau (Kanpur) in the surface water of Ganga River while the values of BaA, BbF and BahA were greater than its suggested value given by RIVM 2012.[11] At Kaushambi, the concentration of BaA, BbF, BkF, BaP, BahA, BghiP, IP were higher than the recommended safe limit suggested by RIVM 2012.[11]

DISCUSSION

Determination of PAHs in some studied Rivers

Although, PAHs in river water have been studied globally by many authors such as Kor River (Iran) Kafilzadeh *et al*.[12] Pearl River (China) Feng *et al*.,[13] Luan River Basin (China) Cao *et al*.,[14] Danube River (Europe) Nagy *et al*.[15] Typically, PAHs contamination in some aquatic bodies is also investigated in India like Adyar River, Cooum River, Ennore Estuary Pulicat Lake, Chennai (Goswami *et al*.),[16] Mahakam River (Hadibarata *et al*.),[17] Bharalu Tributary of Brahmaputra River (Hussain *et al*.),[18] Gomti River (Malik *et al*., J. K. Pandey *et al*.),[19,20] Western coast of India, Mumbai (Masih *et al*.)[21] including Ganga River (Ahmad *et al*.; Srivastava *et al*.; Sharma *et al*.,; Duttagupta *et al*).[22-25] Most of the studies done on the sum of the total PAHs and individual PAHs are less investigated. In the present study, the mean concentration of total PAHs shown as 6.6732±6.8425, 1.6752±0.4532 and 1.4233±0.6509 at Jajmau (Kanpur), Katari Bhalepur (Fatehpur) and Kursinda Kachar (Kaushambi) respectively. In the present report, the sum of total PAHs at all three studied stations were detected as comparatively lower than the Mithi River, Lagos Lagoon and also in Ganga River noticed by Singare *et al*,[26] Sogbanmu *et al*. 2019; Sharma *et al*., 2018. In the present findings, it is also determined that Jajmau (Kanpur) was contaminated by 2-4 rings of PAHs same as presented by Agarwal *et al*. 2006 in Yamuna River. Similarly, the total number of PAHs in the present report is comparatively lower than Ganga River studied by (Sharma *et al*).[24] BaP was investigated at two sites Katari Bhalepur (Fatehpur) and Kursinda Kachar (kaushambi) where this concentration (µg/L) was 0.0098 and 0.0283 at Bhalepur (Fatehpur) and Kursinda Kachar (kaushambi) were higher than the concentration 0.008 µg/L noticed by Ahmad *et al*. 1996. The mean concentration (µg/L) of Phe was 0.2443±0.226, 0.1503±0.0997 and 0.0747±0.0131 was analyzed at all three investigated cities Jajmau (Kanpur), Katari Bhalepur (Fatehpur) and Kursinda Kachar (Kaushambi) was higher at Jajmau (Kanpur) and Katari Bhalepur (Fatehpur) while lower at Kursinda Kachar (Kaushambi) noted as 0.001 to 0.018 by Ahmad *et al*.[22] On the contrary, BaP is noted lower in the present report as investigated (8.61 µg/L) in Mithi River by Singare *et al*.[26] The concentration of BaP in the Ganga River at Katari Bhalepur (Fatehpur) and Kursinda Kachar (Kaushambi) was lower than the concentration

0.07 to 0.87 (µg/L) measured by Refai *et al*.,[29] in Nile River. Further, the concentration (µg/L) of Fln was 0.0446 and 0.1136 at Fatehpur and Kaushambi which was lower than 0.14 (µg/L) noted by Refai *et al*.[29] while the concentration (µg/L) of Fln (0.6239) at Kanpur was greater than 0.14 (µg/L) reported by Refai *et al*.[29]

PAHs composition pattern, ring sizes and source identification

Typically, sources of PAHs may be helpful for the management and remediation of PAHs. Anthropogenic sources of PAHs emission can be of two types; pyrogenic and petrogenic. Pyrogenic sources included the burning of fossil fuels found in automobiles, power plants, the coal and oil burning industry, waste incinerators and more,[5-30] while petrogenic sources included crude oil and petroleum products such as kerosene, gasoline, diesel, lubricants and asphalt.[5-31] Volcanic emissions, natural wells, plant debris, wildfires and certain biological processes are included in natural sources.[32] In urban areas, the major sources of PAHs are petrochemical industries, automobile exhausts, coal-fired plants.[33,34] that contributes LMW PAHs or pyrogenic sources, detected in Kanpur. Nap, the indicator of petroleum sources could not be detected in the present study in any sites as it undergoes photo-oxidation and biodegradation in water due to its highly volatile nature at room temperature.[35,36] According to,[37] Phe was found at all three sites (Kanpur, Fatehpur and Kaushambhi), derived from coal combustion. It was noticed that three to four rings PAHs were present at Jajmau (Kanpur) while three to six rings PAHs were dominant in Katari Bhalepur (Fatehpur) and Kursinda Kachar (Kaushambi). Table 2 presents the molecular diagnostic ratio and possible sources of PAHs in the present report. In the present investigation, Ant/Ant+Phe ratios were 0.045 and 0.034 at Kanpur and Fatehpur respectively indicate petrogenic sources.[35] Similarly, the ratio of Phe/Ant in Kanpur and Kaushambi was 21.06 and 27.6 represents petrogenic sources (Table 2). At Fatehpur the ratio of BaA/BaA+Chr was 0.09 showing petrogenic sources while at Kanpur and Kaushambi the ratio of BaA/BaA+Chr were 0.29 and 0.52 indicate pyrogenic sources (Table 2). IP and BghiP were detected in Kaushambi in which the ratio of IP/BghiP was 0.3 showing pyrogenic sources, on contrast the ratio of IP/BghiP was 0.4 showing petrogenic sources (Table 2). BaA and Chr were present in all three cities and source diagnostic ratio showing pyrogenic sources at Jajmau (Kanpur) (Table 2). In present findings, BaA and Chr detected in Fatehpur as well as Kaushambi, showing grass and coal-burning sources (Table 2). BaP is considered one of the most carcinogenic PAHs, used as a marker for risk assessment, and originated from wood and dung-cake combustion[18] which was estimated at Fatehpur and Kaushambi. In these two cities, coal, oil, gas, garbage, wood, dried animal dung cake and crop wastes are extensively used for domestic purposes, which contribute to BaP contamination in Ganga River water. Three to four rings PAHs are found in Jajmau (Kanpur), showing industrial waste incinerators.[38] Furthermore, BbF which is the marker of gasoline and diesel engine was estimated in Fatehpur and Kaushambi. Fln and Phe were measured in all three sites which originated from emission incineration and the source of BghiP (Kaushambi) was emitted from motor vehicles.[38] Chr was investigated in all three cities (Kanpur, Fatehpur and Kaushambi) while BkF was analysed in two cities (Fatehpur and Kaushambi) that originated from coal combustion.[38] LMW PAHs in Kanpur may be attributed to surface runoff, municipal/industrial effluents,

Table 2: Molecular diagnostic ratios and possible sources of PAHs.

Sl. No.	PAHs	Petrogenic	Pyrogenic	Surface water	References
1.	Ant/Ant+Phe	<0.1		0.045 (Kanpur) 0.034 (Kaushambi)	[35]
2.	Phe/Ant	>10	<10	21.06 (Kanpur) 27.6 (Kaushambi)	[40]
3.	BaA/BaA+Chr	<0.2	> 0.35	0.29 (Kanpur) 0.09 (Fatehpur) 0.52 (Kaushambi)	[41,42]
4.	IP/IP+BghiP	<0.2	>0.2	0.3 (Kaushambi)	[42]
5.	IP/BghiP	<0.4		0.4 (Kaushambi)	[38]
6.	BaA/BaA+Chr	<0.2	0.2 – 0.35 Or > 0.35 (Combustion of coal, wood and grass)	0.29 (Kanpur) 0.59 (Fatehpur) 0.52 (Kaushambi)	[43]

Table 3: Primary water quality criteria for surface water.

Sl. No.	Parameters	Water samples		
		Jajmau (Kanpur)	Katari Bhalepur (Fatehpur)	Kursinda Kachar (Kaushambi)
1	Temperature (°C)	21.6±0.1	21.4±0.2	21.03±0.05
2	pH	8.03±0.05	7.76±0.05	7.93±0.05
3	TDS (mg/L)	173.3±1.52	215.3±1.15	165.3±1.52
4	EC (µs/s)	351.6±1.52	416.3±1.15	334.6±0.57
5	Nitrate	5.0ppm	5.0ppm	5.0ppm
6	Nitrite	0.25ppm	0.25ppm	0.25ppm
7	Ammonia	4.00ppm	4.0ppm	0.25ppm
8	DO (mg/L)	2.96±0.12	1.46±0.23	1.6±0.4
9	BOD (mg/L)	0.82±0.26	1.46±0.23	0.26±0.23
10	Hardness (mg/L)	33.3±2.30	94.82±4.98	50±0

transport and atmospheric deposition containing PAHs due to urbanization and energy consumption. LMW and HMW PAHS were investigated in Fatehpur and noticed HMW PAHs present higher than its safe limit recommended by RIVM 2012. Dissolve Oxygen (DO), Biological Oxygen Demand (BOD) were under the safe limit as India REGD. NO. D. L.-33004/99-2000[39] for bathing water. At Fatehpur, the adjoining point of Pandu River which carries most of the domestic and industrial wastes from urban and rural areas contributed to these PAHs. At Kaushambi the highest numbers of (LMW and HMW) PAHs were measured which came from coal, wood and petroleum while Petrogenic inputs may be due to possible leakage of fuel engines of fishing boats, tourists boating and yachts in the area also found that HMW PAHs were present higher than its recommended levels (Table 1). Table 3 shows the lowest level of dissolved oxygen in Kaushambi which led to a slow degradation rate of PAHs in aquatic environment.[20] Therefore the maximum numbers were identified in Kaushambi.

CONCLUSION

Although, present investigation showed that Ganga River water at all study stations was contaminated by PAHs. The total PAHs measured in Ganga River water at all three cities were above the recommended safe limits. However, it is clear from the present report that Fatehpur and Kaushambi were contaminated by HMW PAHs which are more toxic than LMW PAHs. From source identification, it is clear that HMW PAHs were found maximum in Kursinda (Kaushambi) which underlying in rural areas. Most of the water at this site is used for irrigation, bathing and ritual purposes. Therefore, the present study may be helpful for reducing PAHs levels in Ganga River water at the studied station by source measurement.

ACKNOWLEDGEMENT

The author would like to thank UGC for providing the funds required for this research work.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

Nap: Naphthalene; **Acy:** Acenaphthylene; **Ace:** Acenaphthene; **APHA AWWA:** American Public Health Association American Water Works Association; **Flu:** Fluorene; **Ant:** Anthracene; **Flu:** Fluoranthene; **BaA:** Benzo(a)anthracene; **BbF:** Benzo(b)fluoranthene; **BkF:** Benzo(k)fluoranthene; **BaP:** Benzo(a)pyrene; **BghiP:** Benzo(ghi)perylene; **BOD:** Biological oxygen demand; **Chy:** Chrycene; **DbA:** Dibenzo(a.h)anthracene; **DO:** Dissolve oxygen; **EC:** Electrical conductivity; **HMW:** High molecular weight; **HPLC:** High performance liquid chromatography; **ip:** Indeno(1,2,3-cd)pyrene; **LMW:** Low molecular weight; **Pyr:** Pyrene; **Phe:** Phenanthrene; **RIVM:** National Institute of Public Health and Environmental Protection (Rijksinstituut voor Volksgezondheid en Milieu); **TDS:** Total dissolve solid.

SUMMARY

Determination of PAHs have been done in the Ganga River basin at three major cities namely Kanpur, Fatehpur and Kaushambi. It is found that all three cities are contaminated by PAHs. The total PAHs were

measured in Ganga River water at all three cities were above the recommended safe limits, suggested by RIVM 2012. Only LMW PAHs (3 – 4 rings) ware detected in Jajmau (Kanpur) while both types (LMW and HMW) of PAHs were detected in Katari Bhalepur (Fatehpur) and Kurshinda Kachar (Kaushambi) which are more toxic than LMW PAHs.

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Cite this article: Sonwani P, Singh C. Determination of Polycyclic Aromatic Hydrocarbons (PAHs) and their Sources in Ganga River Water, Uttar Pradesh, India. Asian J Biol Life Sci. 2023;12(2):245-52.