Polycyclic Aromatic Hydrocarbons Contents of Sediment and Water in Drainages and Receiving Elechi Creek in Port Harcourt Rivers State Nigeria

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ABSTRACT

The levels of polycyclic aromatic hydrocarbons were assessed in sediment and water from drainages and its receiving Elechi creek Rivers State, Nigeria. The levels of polycyclic aromatic hydrocarbons (PAHs) were determined by using standard methods recommended by the American Society for Testing and Materials with Gas Chromatography-Mass Spectroscopy (GC-MS). The results from the study showed PAHs levels in water and sediments to be above USEPA limits with naphthalene (34.72ppm), Dibenzo [a, h] anthracene (113.63ppm) and Benzo [g,h,i] peylene (34.51ppm) being prominent.

Keywords: Polycyclic Aromatic Hydrocarbon, Sediment, Water, Drainage, Port Harcourt.

INTRODUCTION

Studies in the last few years have shown the presence of more than 600 organic compounds in the environment, the most important of which belong to the classes: petroleum hydrocarbons, aldehyde, polycyclic aromatic hydrocarbons (PAHs), ketones and alcohol (Grynkiewicz *et al*., 2002, Sibiya, 2012). Due to the difference in the physicochemical properties of organic contaminants, PAHs tend to interact to different extent with sediments, water and biota. The dynamics of a river or dam ecosystem are complex with some PAH pollutants adsorbed unto organic matter while others dissolve, volatilize or undergo microbial degradation. Many PAHs are at the same time persistent, bioaccumulative and toxic for humans and aquatic organism (Ahmadzadeh *et al*., 2011, Sany *et al*., 2014).

Polycyclic aromatic hydrocarbons(also known as polyaromatic hydrocarbons or polynuclear aromatic hydrocarbons)(PAHs)are persistent organic pollutants of high environmental concern with known carcinogenic activity (Bathi *et al*., 2012). They constitute a large group of organic compounds containing two or more fused aromatic rings arranged in linear, angular or cluster mode and containing carbon and hydrogen atoms only. The presence of polycyclic aromatic hydrocarbons (PAHs) in water and sediments can create a serious hazard to public health and the environment due to their widespread occurrence, strong persistence, long-range transportation potential, carcinogenic, mutagenic and teratogenic properties as well as their high environmental concentration (Okafor and Opuene, 2007).

Numerous PAHs occur in the environment, but the United States Environmental Protection Agency (USEPA) and the European Commission have listed 16 PAHs as priority pollutants. These are naphthalene, acenaphthalene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenz[a,h]anthracene and benzo[g,h,i]perylene (Nino *et al*., 2014; Edokpayi *et al*., 2016).

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PAHs are lipophilic compounds with very low water solubility and therefore, their concentration in water is very low (Kafilzadeh *et al*., 2011). As a consequence of PAHs' hydrophobic properties, they tend to settle out of water and accumulate in the bottom sedimentation. Therefore, concentration of PAHs should be high in the sediments of polluted aquatic environments (Kafilzadeh *et al*., 2015).

PAHs can be released from their sources either in a gas phase or they can be associated with particles by nucleation and condensation, forming particulate matter. Once produced, PAHs can be widely dispersed into the environment by atmospheric transport or through stream pathways and eventually accumulate in soils and aquatic sediments (Liu *et al*., 2013); they can be transported into an aquatic environment by a number of pathways including fossil fuel distribution, petroleum spillage, storm water and surface runoff, sewage and waste water effluent, and eventually accumulate in soils and aquatic sediments (Liu *et al*., 2009). Other sources of PAHs to the aquatic and sediment environments include creosote-treated products, spills of 10 petroleum products from leaking tanks and bunkering activities, industrial plants and waste water treatment plants, and deposition of atmospheric PAHs. The main industrial (stationary) sources of PAHs include coke oven, aluminum production, iron and steel foundries, coal gasification and coke production (Dubey *et al*., 2013). Both anthropogenic activities and natural emissions are the PAH sources of coastal sediments (Kafilzadeh, 2015).

The adverse effect of PAHs on human health as a result of inhalation of their dust particles have been described as the most detrimental to human health (Sibiya, 2012). These compounds can enter the body through inhalation of vapour from the soil, intake of contaminated drinking water and skin exposure via dermal contact. Also soil ingestion has been recognized to be as an important exposure route as water and food to human (Mostert, 2008). The effects of PAHs are mostly known from animal experiments; researchers have reported increased incidences of skin, lung, bladder, liver, and stomach cancers (ATSDR, 2009). Animal studies show that certain PAHs also can affect the hematopoietic and immune systems and can produce reproductive, neurologic, and developmental effects (ATSDR, 2009).

Nwineewii and Marcus, (2015) studied the concentrations and toxicological effects of polycyclic aromatic hydrocarbons (PAHS) in Eleme and Okrika creeks of Niger Delta (Nigeria). The results obtained from the studies showed that the concentrations of PAHs ranged between 0.008 and 0.249 mg/L From the results, it was observed that the concentrations of the pollutants were higher than the USEPA recommended limits for drinking water. Tongo *et al.* (2017) in a review of the levels, distribution and characterization of PAHs in Ovia river, Southern Nigeria reported that total PAH concentrations in water were generally higher than the WHO guideline value of 0.05 µg/L for PAHs in drinking water. Adeniji *et al*. (2019) investigated the levels of polycyclic aromatic hydrocarbons in the water and sediment of Bufalo river estuary, South Africa and their health risk assessment. Results from the study showed that total levels of the contaminants were above the target values in the two matrices and were higher in summer than autumn. Although the non-carcinogenic risk of PAHs estimated in the water column through dermal absorption was very low compared with the target value, the carcinogenic risk determined was high for both adults and children.

The Study Area, Diobu is located in Port Harcourt City Local Government Area (PHALGA) of Rivers State in Nigeria. It is a densely populated neighborhood consisting of mile 1, mile 2 and mile3 having good streets network. It houses two major markets in Port Harcourt; the Mile 1 and Mile 3 markets as well as the Ikoku spare parts market and the mile 3 timber market. It is the hub of commercial activities in Port Harcourt. Diobu is bordered by new Government residential area (GRA) to the East, D/Line to the North-East, Rivers State University to the North-West, Old G.R.A to the East, Eagle Island to the South-West.

Mile one Diobu is located between Latitudes 40 47' 24"N and 40 49' 00" N, and longitudes between 60 59' 00" E and 70 01' 00", with an elevation of 468m. The area has the same weather condition like Port Harcourt as a region the climatic condition is the tropical climate. Mile One features a humid tropical climate with rainfall starting from the month of February through the month of November, while only the months of December and January truly qualifies as dry season months in the city. Rainfall is seasonal, variable, and heavy in Mile one Diobu. The mean annual temperature for Mile one Diobu is 26°C just as the case of Port

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Harcourt. It has approximately 30 streets and one of the largest markets in Port Harcourt. The market is surrounded by residential buildings, banks, Police Station, recreational park, commonly known as Isaac Boro Park, and car parks. Mile one in Diobu is a residential and commercial area as it attracts traders from different parts of Port Harcourt for the purposes of business transactions. Businessmen converge on daily basis to transact their businesses (Chukwu-Okeah, 2012). The map of the study area is shown in Figure 1.

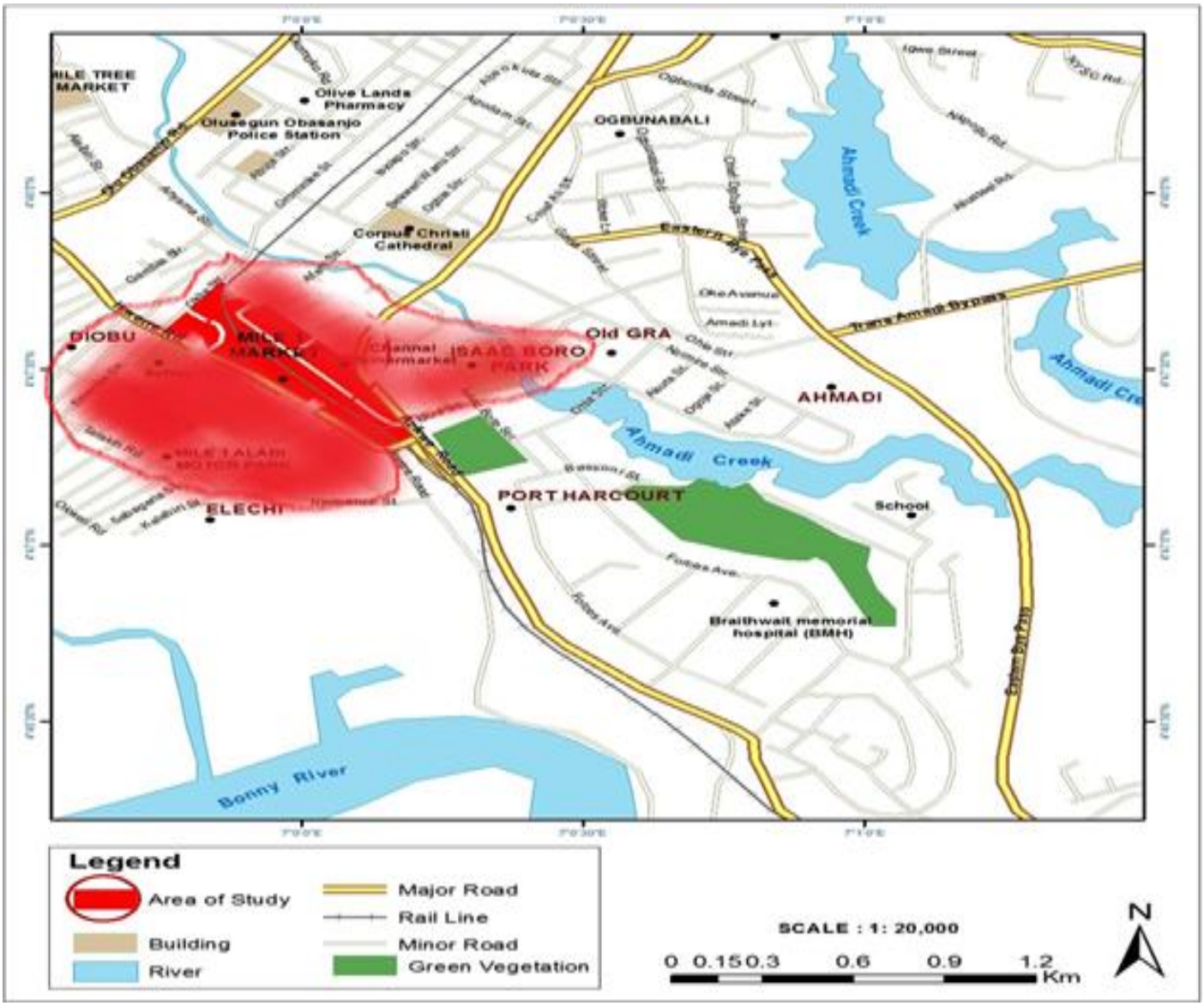

Fig. 1: Map of Port Harcourt Showing Study Area.

MATERIALS AND METHODS

Sample Collection and Preparation

Samples for the study were water and sediment. The samples were collected at different strategic location of the study area. Water samples were collected at 8 stations identified as (1) Urualla by Abakaliki Junction (2) Ikwerre Street (3) Njemanze by Awgu Street(4) Ojike by Abakaliki Street (5) Udi Street (6) Urualla by Illoabuchi Street (7) Urualla/Ojike/Elechi Water Front(8) Urualla/Ojike Elechi creek with a pre-rinsed glass bottles for analysis of PAH. All the samples were transported with ice packs within an hour to the laboratory.

Sediments were collected with the aid of a trowel to a depth of 0.5cm. Sediment samples were collected from the drains and at different locations where the drains empty into the creek. The samples were immediately wrapped in aluminum foil to avoid contamination and taken to the laboratory.

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Determination of Polycyclic Aromatic Hydrocarbons

An extraction solvent of acetone and methanol in a ratio of 3:1 were prepared. 10 g aliquot of well-mixed samples (water and sediment) was measured into a solvent-rinsed beaker. Anhydrous sodium sulfate was used to dry wet samples until particles were loose. The sample were then placed in the sonicator and sonicated for about 5-10 min at about 700℃. The extract was filtered through a glass funnel with glass wool and anhydrous sodium sulphate. The extract transferred to a Teflon-lined screw-cap vial ready for PAH analysis. The instrument used was Agilent 5890B GC system 5977A MSD system and Agilent 7890A GC system 5975C inert XL MSD. The instrument was calibrated before sample analysis was carried out.

RESULTS AND DISCUSSION

Levels of PAHs in Water and Sediments

The levels of PAHs in sediments and water are presented in Tables 1 and 2. PAHs levels in water in all stations ranged from 0.01±0.0 to 0.82±0.01 ppm. PAHs levels in the sediments in all the stations ranged from 0.01±0.0 to 113.63±1.2 ppm.

Table 1: Levels of Polycyclic Aromatic Hydrocarbons in Water

Parameters (ppm)	Station1	Station2	Station3	Station4	Station5	Station6	Station7	Station8	USEPA LIMIT
Naphthalene	0.82±0.01	0.22±0.01	0.38±0.0	0.08±0.01	0.1±0.0	0.08±0.01	0.1±0.0	0.04±0.0	4.0×10^{-2} c
Acenaphthylene	0.08±0.01	0.05±0.01	0.05±0.0	0.03±0.0	0.04±0.0	0.09±0.0	0.08±0.0	0.02±0.0	2.0×10^{-1} b
Acenaphthene	0.17±0.0	0.35±0.02	0.05±0.0	0.05±0.0	0.05±0.0	0.06±0.0	0.04±0.0	0.01±0.0	2.0×10^{-1} b
Fluorene	0.71±0.0	0.07±0.0	0.07±0.0	0.05±0.0	0.09±0.0	0.08±0.0	0.1±0.0	0.04±0.0	2.0×10^{-1} b
Phenanthrene	0.07±0.0	0.05±0.0	0.03±0.0	0.04±0.0	0.05±0.0	0.02±0.0	0.03±0.0	0.02±0.0	2.0×10^{-1} b
Anthracene	0.11±0.0	0.03±0.0	0.09±0.0	0.05±0.0	0.02±0.0	0.04±0.0	0.02±0.0	0.01±0.0	2.0×10^{-1} b
O-Terphenyl	0.01±0.0	0.01±0.0	0.01±0.0	0.01±0.0	0.01±0.0	0.01±0.0	0.01±0.0	0.01±0.0	2.0×10^{-1} b
Fluorathene	0.07±0.0	0.03±0.0	0.05±0.0	0.02±0.0	0.02±0.0	0.01±0.0	0.01±0.0	0.01±0.0	2.0×10^{-1} b
Pyrene	0.03±0.0	0.02±0.0	0.01±0.0	0.02±0.0	0.01±0.0	0.02±0.0	0.01±0.0	0.01±0.0	2.0×10^{-4} b
Benzo[a]anthracene	0.34±0.0	0.07±0.0	0.1±0.0	0.05±0.0	0.11±0.0	0.1±0.0	0.06±0.0	0.06±0.0	2.0×10^{-4} a
Chrysene	0.2±0.0	0.03±0.0	0.08±0.0	0.02±0.0	0.04±0.0	0.05±0.0	0.03±0.0	0.06±0.0	2.0×10^{-4} a
Benzo[b]fluoranthene	0.12±0.0	0.08±0.0	0.1±0.0	0.02±0.0	0.03±0.0	0.06±0.0	0.08±0.0	0.1±0.0	2.0×10^{-4} a
Benzo[k]fluoranthene	0.59±0.02	0.02±0.0	0.04±0.0	0.01±0.0	0.02±0.0	0.03±0.0	0.04±0.0	0.06±0.0	2.0×10^{-4} a
Benzo[a]pyrene	0.06±0.0	0.06±0.0	0.11±0.0	0.09±0.0	0.09±0.0	0.04±0.0	0.1±0.0	0.12±0.03	2.0×10^{-4} a
Dibenzo[a,h]anthracene	0.26±0.0	0.67±0.0	0.17±0.01	0.34±0.02	0.47±0.0	0.25±0.01	0.2±0.0	0.16±0.01	3.0×10^{-4} a
Indeno[1,2,3-cd]pyrene	0.23±0.0	0.21±0.0	0.18±0.0	0.15±0.0	0.21±0.0	0.32±0.03	0.38±0.02	0.48±0.02	4.0×10^{-2} c
Benzo[ghi]perylene	0.11±0.0	0.06±0.0	0.05±0.0	0.03±0.0	0.05±0.0	0.03±0.0	0.04±0.0	0.03±0.0	4.0×10^{-2} c

USEPA Limits: a = 2013; b = 2014; c = 1996

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Table 2: Levels of Polycyclic Aromatic Hydrocarbons in Sediments

Parameters (ppm)	Station1	Station2	Station3	Station4	Station5	Station6	Station7	Station8	USEPA LIMIT
Naphthalene	0.47±0.02	1.62±0.02	0.28±0.0	0.77±0.0	0.94±0.0	0.09±0.0	34.72±1.32	7.66±0.08	4.0×10^{-2} c
Acenaphthylene	0.14±0.0	0.34±0.0	0.1±0.0	0.13±0.0	0.11±0.0	0.08±0.01	1.48±0.02	0.24±0.0	2.0×10^{-1} b
Acenaphthene	0.19±0.0	1.31±0.01	0.06±0.0	0.13±0.0	0.2±0.0	0.07±0.0	7.85±2.43	0.2±0.0	2.0×10^{-1} b
Fluorene	3.67±0.05	3.38±0.02	4.44±1.41	0.98±0.02	2.63±0.02	1.18±0.03	4.22±0.08	3.24±1.12	2.0×10^{-1} b
Phenanthrene	0.16±0.0	0.43±0.04	0.05±0.0	0.07±0.0	0.15±0.01	0.1±0.0	1.1±0.01	0.35±0.0	2.0×10^{-1} b
Anthracene	0.1±0.0	0.35±0.03	0.19±0.0	0.11±0.0	0.1±0.0	0.03±0.0	0.93±0.0	0.14±0.0	2.0×10^{-1} b
O-Terphenyl	0.01±0.0	0.01±0.0	0.01±0.0	0.01±0.0	0.02±0.0	0.01±0.0	0.03±0.0	0.02±0.0	2.0×10^{-1} b
Fluorathene	0.02±0.0	0.06±0.0	0.02±0.0	0.03±0.0	0.04±0.0	0.03±0.0	0.13±0.0	0.06±0.0	2.0×10^{-1} b
Pyrene	0.05±0.0	0.1±0.0	0.03±0.0	0.04±0.0	0.08±0.0	0.03±0.0	0.08±0.0	0.04±0.0	2.0×10^{-4} b
Benzo[a]anthracene	0.04±0.0	0.08±0.0	0.05±0.0	0.06±0.0	0.08±0.0	0.04±0.0	0.08±0.0	0.08±0.01	2.0×10^{-4} a
Chrysene	0.05±0.0	0.05±0.0	0.04±0.0	0.05±0.0	0.05±0.0	0.05±0.0	0.08±0.0	0.08±0.01	2.0×10^{-4} a
Benzo[b]fluoranthene	0.1±0.0	0.12±0.0	0.04±0.0	0.12±0.0	0.05±0.0	0.13±0.0	0.15±0.0	0.23±0.02	2.0×10^{-4} a
Benzo[k]fluoranthene	0.05±0.0	0.06±0.0	0.09±0.0	0.05±0.0	0.02±0.0	0.08±0.0	0.06±0.0	0.07±0.0	2.0×10^{-4} a
Benzo[a]pyrene	0.05±0.0	0.46±0.01	0.11±0.02	0.22±0.0	0.11±0.0	0.33±0.0	0.17±0.0	8.58±1.41	2.0×10^{-4} a
Dibenzo[a,h]anthracene	113.63±1.2	13.56±0.42	0.85±0.01	0.6±0.0	1.1±0.04	0.07±0.0	0.31±0.0	1.16±0.04	3.0×10^{-4} a
Indeno[1,2,3-cd]pyrene	0.53±0.03	0.49±0.01	0.19±0.0	0.29±0.0	0.69±0.0	0.25±0.0	0.27±0.0	0.65±0.0	4.0×10^{-2} c
Benzo[ghi]perylene	34.51±1.41	1.7±0.02	0.07±0.0	0.3±0.0	0.2±0.0	72.1±2.41	1.2±0.03	0.15±0.0	4.0×10^{-2} c

USEPA Limits: a = 2013; b = 2014; c = 1996

PAHs in water ranged from 0.01±0.0 to 0.82±0.01ppm in the stations. Naphthalene at station 1 has the highest value of 0.82±0.01ppm. O-terphenyl had the lowest value of 0.01±0.0in station 1 to station 8. The PAHs in the water across the stations exceeded USEPA acceptable limits except Acenaphthylene, phenanthrene, O-terphenyl and fluoranthene. PAHs in sediments range from 0.01±0.0 to 113.63±1.2 ppm across all stations. Dibenzo (a,h) anthracene at station 1 has the highest value of 113.63±1.2 ppm. The PAHs of the sediments were above the USEPA acceptable limits. Some stations recorded low concentrations while others were high. For those stations where the concentrations were lower, it could be attributed to be distance from the point source occasioned with gradual dilution of the pollutant. The high concentrations recorded in some stations could be due to the closeness of stations to point source. These results pose serious environmental concerns as water and sediments from the drainages empties itself into the river which the populace use for fishing purposes. Also faunas for daily consumption are gotten from the river and they are liable to health risk due to excess dumping of the waste in the drainage leading to more concentrations of PAHs compounds in water and fauna specie. Most PAHs in our environment in addition to their presence in fossil fuels are a result of incomplete combustion of carbon containing materials such as oil, wood, garbage, diesel, fat, tobacco, incense and coal (BBC NEWS, 2001). The health effects of PAH compounds are not stereotyped; the individual PAH compounds have different health effects (Rengaranjan *et al.*, 2015). Some PAHs are well known as carcinogens, mutagens and teratogens and therefore pose a serious threat to the health and well-being of humans. The most significant health effect to be expected from exposure to PAHs is decreased immune function, cataracts, kidney and liver damage (e.g. jaundice), breathing problems, asthma-like symptoms, and lung function abnormalities (Rengaranjan *et al.*, 2015).. Naphthalene, a specific PAH, which results showed to be above the acceptable limits can cause breakdown of red blood cells if inhaled or ingested in large amounts (Rengaranjan *et al.*, 2015).

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CONCLUSION

Results from the determination of polycyclic aromatic hydrocarbons concentrations of sediments, water of drainages and its receiving river showed that PAHs in water and sediments were above USEPA limits with naphthalene, Dibenzo [a, h] anthracene and Benzo [g,h,i] perylene very prominent.

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