Determination of Atmospheric Particulate Matter Polycyclic Aromatic Hydrocarbons (PAHs) in Al-Diwaniyah City, Iraq.

Original Research Article

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ABSTRACT

The current study was conducted to determine Polycyclic aromatic hydrocarbons (PAHs) in the atmospheric total suspended particles (TSP) in Al-Diwaniyah city southern of Iraq. To achieve this, seven sites were identified in different location within the city. The results showed that the annual mean of PAHs concentrations ranged between non-detectable (ND) for Phen and BaA, and 2621.62 $ng.m^{-3}$ for Chry. The findings showed that the annual mean of ∑11 PAHs reach 5031.44 $ng.m^{-3}$. The results also showed that the human activities was the main sources of PAHs atmospheric pollution especially fossils fuel combustion for energy generation an transportation.

KEYWORD:

Total suspended particles, PAHs, fossils fuel combustion, carcinogenic.

I. INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are widespread environmental pollutants that are formed by incomplete combustion processes of organic matter naturally or as a result of human activities (Chantara and Sangchan, 2009). Which have a wide range of chemical compounds that pose serious risks to human health, mainly due to their carcinogenic properties (Chlopek *et al.*, 2016). Polycyclic aromatic hydrocarbons are a large group of organic compounds that contain two or more of the fused-aromatic rings and are characterized by low solubility in water, high affinity to lipids, and many of which have low vapor pressure in the air, thus its tend to adsorption with atmospheric particulate matter (Srogi, 2007). PAHs are released into the atmosphere from natural and anthropogenic sources as a result to incomplete combustion or pyrolysis processes at high temperatures of fossil fuels and other organic matter (Nguyen *et al*., 2010). Natural sources include forest fires, volcanic eruptions and the re-suspension of contaminated dust in the air by wind. Anthropogenic sources include the combustion of fossil fuels in industry, transportation, energy production, and burning of biomass, coal, waste, plastics, cigarette smoking, and soot (Li-bin *et al*., 2007; Bi *et al*., 2008).

When released into the atmosphere, PAHs are redistributed between the gaseous and airborne particulate matter, which helps to transfer them to wide distances before they are finally removed from the atmosphere by sedimentation on soil and water. Although PAHs can travel to long distances the larger sedimentation are observed near their emission sources (Nassar *et al*., 2015).

The distribution of PAHs between gaseous and solid states is related to various variables such as the type of compound, vapor pressure, temperature, as well as the size, chemical structure and surface area of suspended particles, and these properties governed the way by which they are distribution in the atmosphere (Li- bin *et al*., 2007).

It has been found that PAHs containing three rings of benzene or less have a low molecular weight and possess high vapor pressure, so its usually found in the gaseous phase as a vapor and this feature makes it highly mobile among the different environmental media through sedimentation and re-volatilization between air, soil and water body. While the PAHs compounds containing five rings or more have a large molecular weight and low vapor pressure and therefore are less volatile and mainly associated with the suspended particles in the air and this enhances their transmission to far distances and approximately cause its presence everywhere in the environment (Zuydam, 2007).

The ultimate fate of PAHs in nature is their transformation into contaminants of great importance in terms of their effects in the health of the environment and humans, this is due to their wide spread, stability, ability to long distances transport, carcinogenic and mutagenic properties, as well as high concentrations and occurrence frequency in the environment (Azhari, 2012).

PAHs and some of their derivatives are common contaminants characterized by the difficulty of biodegradation in the environment, many of which cause cancer, genetic mutations and disruption of endocrine secretion even at relatively low levels (Nassar *et al*., 2015). And has received great attention by researchers in previous years because of its effect on the endocrine system, which causes dysfunction in this organ, both in humans or other wildlife, leading to cancer and congenital malformations as well as weak immune system (Hayakawa, 2009).

II. MATERIALS AND METHODS

Study area:

The present study was conducted in the city of Al-Diwaniyah southern of Iraq. Seven stations were identified with different human activities to determine the role of these activities in the generation and release of these pollutants into the air, as shown in Table (1) and Figure (1):

Table (1) shows the locations, specifications and activity of study sites.

Site No.	location	Activity	East	North
1	Al-Mawakeb street	Traffic and commercial	55° 44' 37.69"	59° 31' 11.89"
2	Doctors street	Traffic and industrial	55° 44' 07.62"	58° 31' 54.41"
3	Al-Wahdah district	Residential	56° 44' 19.23"	59° 31' 24.79"
4	Al-Jamieh district	Residential	52° 44' 36.91"	59° 31'43.24"
5	North Al-Diwaniyah power plant	Energy production and Residential	54 ° 44'03.75 "	01 ° 45'47.45"
6	East Al-Diwaniyah power plant	Energy production and traffic	58° 44' 24.15"	59° 31' 39.91"
7	Reference site	Agricultural	51° 44' 16.11"	58° 31' 38.16"

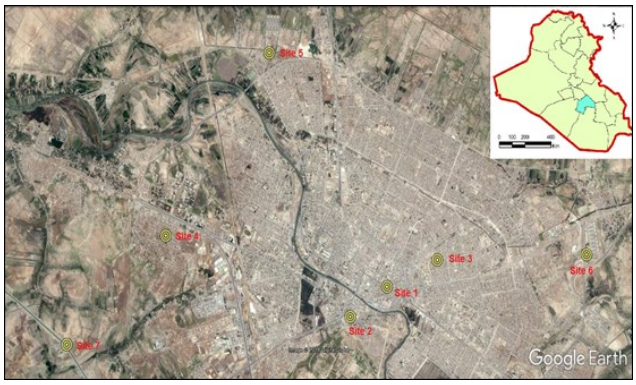

Figure (1) shows study area.

Sampling:

PAHs adsorbed suspended particles samples were collected monthly from September 2016 to August 2017 by air sampler model HI-Q (D-AFC-50), using known weight glass filters type Whatman glass microfiber after it placed in oven at 400 °C for five hours (USEPA, 1999a). After collecting samples, the filters are placed in glass container and kept away from light at a temperature of -20 °C until the extraction of PAHs (Wang et al., 2006).

Analysis:

After cutting the filters into small pieces, place them in sealed glass containers and extract three times with 5 ml of Dichloromethane (DCM) solvent for 10 minutes in the ultrasonicator at maximum power at 10 °C (Wang *et al*., 2006). The extract then is concentrated by nitrogen gas and purified from the residue of the filter fiber and moisture by passing it into a column contain 0.5 g of anhydrous sodium sulphate, the column then washed with 10 ml of DCM and the extract are concentrated to 1 mL with nitrogen. The samples are kept at -20 °C until Measurement (Delgado-Saborit *et al*., 2010).

PAHs were measured by injecting 1 µl of samples extract in the GC model Schimadzu 2010 with FID detector using a SE-30 capillary column (30 m x 0.32 mm x 0.25 µm film thickness) according to the following measurement conditions:

Injector: Splitless
Injector temp: 280 °c
Detector temp: 330 °c
Column oven: 120 °c (hold 1 min) - 300 °c (10 °c / min) (hold 4 min).

From the preparation of a standard curve for eleven PAHs, Naphthalene (Nap), Acenaphthylene (Acy), Fluorene (Flu), Phenanthrene (Phen), Anthracene (Anth), Benzo (c) phenanthrene (BcP), Pyrene (Pyr), Benz (a) anthracene (BaA), Chrysene (Chry), Benzo (a) fluoranthene (BaF), Dibenzo (ah) anthracene (DahA) the concentration of these compounds are determined in air samples and expressed in ng.m^{-3} (USEPA, 1999a).

III. RESULTS AND DISCUSSION

The results table (2) showed that the annual means of PAHs in the air suspended particles recorded undetectable values of Phen at site 3, 4 and BaA at site 3 during the study period. This is due to the fact that these compounds consist of three rings, and have a low molecular weight and a high vapor pressure, so it tends to be in a gaseous state rather than a adsorbed with the suspended particles (Zuydam, 2007). This explains its undetectable concentrations. While the highest values for the annual means have been recorded for Chry, BaF and DahA (Fig. 2), These compounds have a high molecular weight of 228.3, 252.3 and 278.35 respectively so that they found in the suspended particles (Kuusimaki *et al*., 2003). These results coincided with what Kumar (2008) found when studying PAHs in Brisbane, Australia.

Also the annual means of the total PAHs recorded the highest values in the fifth site (Fig. 3), This is due to that this region contains several sources of PAHs, including an electric power station (North Al-Diwaniyah diesel power plant) which works by crud oil, that the combustion of crude oil is the second largest source after the transportation for the PAHs emissions (Lai *et al*., 2017), and this site is located on the main street linking between east and west of the city, which has great traffic for different modes of transport that contribute significantly to increasing PAHs concentrations resulting from exhaust emissions (Marynowski *et al*., 2004). Also the spread of domestic and residential power generators contributes significantly to increase the concentrations of PAHs in this site (Lin *et al*., 2017). While the lowest value was recorded at the seventh site because this area is agricultural and far from the different sources of pollutants release. It was observed from the results of the study that the mean of annual concentration of the total PAHs in different sites have taken the following gradient:

Station 5 > Station 1 > Station 4 > Station 3 > Station 2 > Station 6 > Station 7.

Table (2) shows the annual means of PAHs ng.m^{-3} (mean±SD)

PAHs	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
Nap	17.03±58.99	2.96±10.26	63.23±219.05	97.62±267.29	54.59±131.95	89.78±192.15	99.23±312.86
Acy	202.66±702.03	16.93±48.26	57.35±183.81	69.9±211.28	21.76±75.36	63.78±206.0	2.94±10.19
Flu	27.05±93.71	7.82±27.08	78.07±202.79	71.26±230.31	38.5±103.4	32.6±67.03	173.32±528.55
Phen	11.11±38.5	4.82±16.69	ND	ND	7.79±26.98	37.69±71.82	5.44±18.83
Anth	231.46±411.55	80.25±125.96	87.34±140.3	133.75±298.82	153.76±312.45	56.51±79.2	42.94±75.92
BcP	19.54±45.73	28.77±68.45	132.67±404.28	296.26±767.65	24.36±57.33	186.6±365.62	47.09±126.21
Pyr	89.78±134.46	24.83±40.54	28.15±56.15	29.84±88.77	75.75±149.3	15.47±26.02	13.08±24.32
BaA	22.82±64.22	77.81±170.51	ND	20.26±60.26	44.61±91.55	51.51±105.12	10.07±23.53
Chry	1761.69±2670.32	1499.18±1711.58	1053.4±1925.93	1081.68±2700.47	2621.62±5037.92	1110.44±1394.02	245.67±383.94
BaF	368.67±656.77	307.1±337.64	309±455.21	495.89±761.5	739.42±1298.83	227.96±249.08	78.42±134.36
DahA	766.18±1392.84	241.39±422.72	696±1046.92	521.31±1103.53	1249.31±2590.72	361.23±397.43	307.65±692.75
∑11 PAHs	3517.98	2291.85	2505.21	2817.76	5031.44	2233.57	1025.84

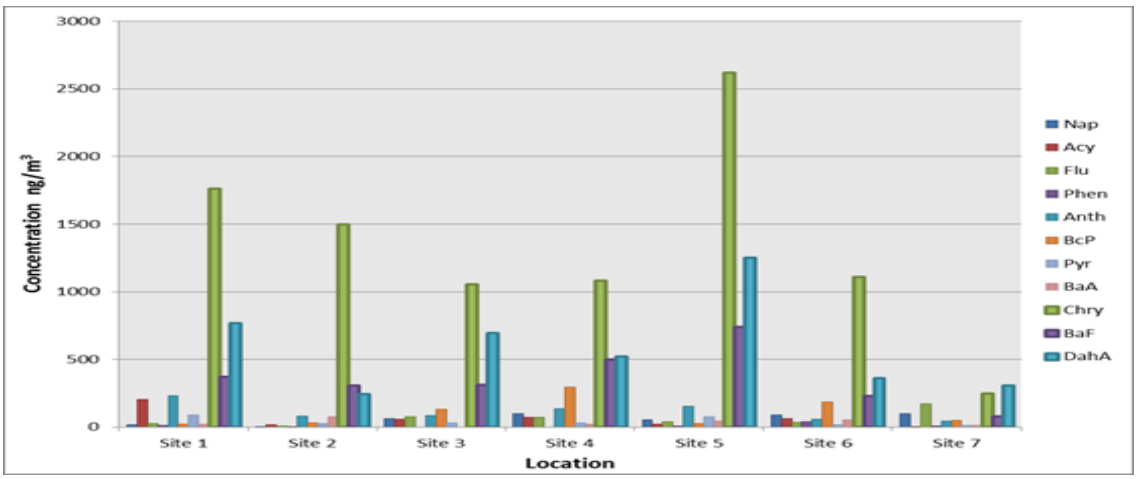

Figure (2): annual means of PAHs compound in different sites.

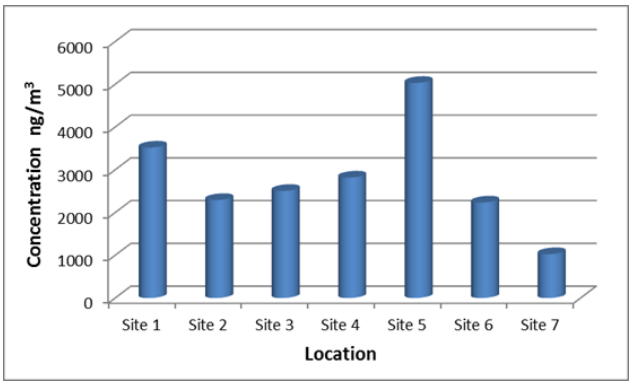

Figure (3): annual means of ∑11PAHs in different sites.

IV. CONCLUSIONS

The results showed that high molecular weight polycyclic aromatic hydrocarbons such as Chrysene, Benzo (a) fluoranthene and Dibenzo (ah) anthracene were the most present in the total suspended particles due to their low vapor pressure. It also showed that various human activities such as power generation, transportation and combustion of crude oil were the most important sources of PAHs into the atmosphere.

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