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HEALTH RISK EVALUATION OF TOXIC POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN THE STREET DUST OF BASRA, IRAQ

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Background: *Dust particles on the surface of urban streets considered among the greatest sources for contamination of urban atmospheres in the form of fine aerosols. This study aimed at determining the concentration of polycyclic aromatic hydrocarbons (PAHs) in the dust samples collected from Basra city streets to evaluate their potential risks to ecosystem, especially, the risk of cancer from dermal contact, inhalation and ingestion.* ***Methods:*** *PAHs in street dust samples from Al- Shafi, Al-Qurna, Al Seeba, Abu Kaseeb, Al- Fao and Al- Burjessya were measured using gas chromatography/mass spectrometry (GC/MS) in Basra.* ***Results:*** *The important PAHs contaminants classified by US EPA detected in the samples, the main was the 3 fused aromatic rings PAHs (79.82%), followed by 5 rings PAHs (7.9%), 4 rings PAHs (6.6%), 6 rings PAHs (5.4%) and 2 rings PAHs (0.5%). Exposure doses ranged from 6.47E-07 to 1.24E-06 ug/g day for child non-carcinogen and 3.65E-07 to 7.02E-07 ug/g day for adult non-carcinogen.* ***Conclusion:*** *Exposed daily doses less than EPA suggested safe daily doses. Hazard quotient HQ values lower than one in all sites, revealed no hazard on health from non-carcinogens. The cancer risk from inhalation was 5.55E-08 to 1.07E-07 for child Carcinogen and 1.25E-07 to 2.41E-07 for adult Carcinogen; it is less than 10^{-4} within the harmless levels. Carcinogenic risk from inhalation two times less than that of dermal and ingestion.*

Key words: *polycyclic aromatic hydrocarbons (PAHs); street dust; Basra.*

INTRODUCTION

Dust particles on the surface of urban streets considered among the greatest sources for contamination of urban atmospheres in the form of fine aerosols[1]. These particles considered as one of the guides for monitoring of urban environmental contaminations[2]. Urban streets dust contain a mixture of contaminants from different sources such as vehicular exhaust, leaks and spillages from vehicles, brake pad wear dust, tire dust and street surface erosion materials, in addition to plant fragments and animals remnants[3]. Therefore, urban street dust often contaminated with organic compounds and a various toxic materials including polycyclic aromatic hydrocarbons (PAHs)[4-6]. PAHs level in water, food, marine and sediment are widely affected by the street dust contamination with PAHs[7]. People crossing the streets and people live in the locality exposed to these contaminants by direct inhalation of dust particles, or by ingestion from contaminated hands, or by eating contaminated vegetables and fruits, or through dermal contamination[8&9]. PAHs are organic compounds long-standing and omnipresent air contaminants in the environment. Most of PAHs compounds are white, pale yellow or colorless solids with numerous structures and diverse toxicity[10]. They exerts their toxicity through interfering with the membranes enzyme systems and the membranes cellular function. PAHs have various toxic effects; it can be carcinogenic, mutagenic or strong immunosuppressant effects[11]. United States Environmental Protection Agency (US EPA) and United Nations Environment Program (UNEP) classify sixteen parental PAHs as important contaminants and persistently toxic substances because of their strength, wide distribution in dust and their powerful toxicity

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exhibiting carcinogenic and mutagenic effects[12].

In order to reduce the risk of environmental exposition to PAHs, it is important to measure quantitatively the supply from different PAHs sources, such as petrol or pyrogenic sources, which considered as the main sources of environmental PAHs[1].

PAHs chemical structure composed of two or more of benzene rings attached in different arrangements. Generally, PAHs resultant from petrol origin such as crude oil or products of petroleum contains three or four rings. Whereas, PAHs from pyrogenic origins contains four to six rings in their structure and they formed when the organic materials exposed to special circumstances of low or no oxygen and elevated temperatures[13].

Basra is one of the most important cities in Iraq, because of the presence of oil Refining and petrochemical Industries. However, there is no published data about toxic PAHs in the street dust from Basra and its potential risk to health. Therefore, this study aimed at determining the concentration of PAHs in the dust samples collected from Basra city streets. In addition, to evaluate potential risks to ecosystem, especially, the risk of cancer from dermal contact, inhalation and ingestion exposure to PAHs in dust street.

MATERIALS AND METHODS

Study area

Basra province (Latitude: 30°30′30″ N and Longitude: 47°46′49″ E), as one of the most important cities in Iraq, with the area of about 181 km^2 and 2.5 million inhabitants in 2012. It is located in the south of Iraq, bordering Kuwait to the south and Iran to the east.

Sample collection and preparation

In August 2019, six (6) street dust samples collected from various locations nearby to oil refineries and petrochemical industries areas in the city of Basrah, samples areas are: Al- Shafi, Al-Qurna, Al Seeba, Abu Kaseeb, Al- Fao and Al Burjessya, shown in (Figure 1). The samples were taken in the dried month of the year to avoid the rain that can wash away the dusts on the streets. Around 250 g of a compound street dust sample taken by brushing an area from the sidewalk of about 1.5×1.5 m^2. The samples passed through a 63-µm mesh and placed in sterilized containers.

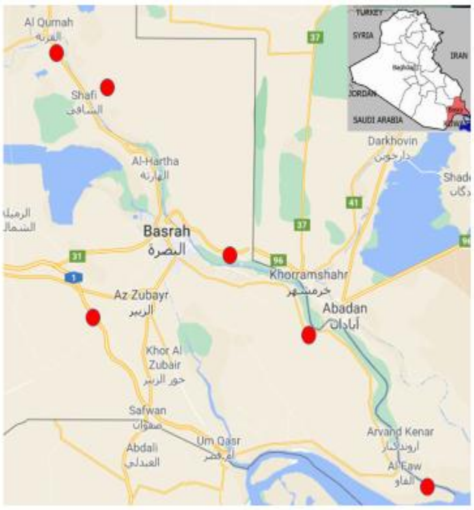

Fig. 1: Map showing the study area and the sampling sites (red circles), samples collected nearby to petrochemical industries and refinery areas of the city locations in Basrah, Iraq.

Samples Analysis for PAHs

PHAs extracted from the dust street samples, about 25g of Dust Street extracted using a soxhlet with 250 ml methanol: benzene (1:1) for 24 – 36 hours. After that saponification was done using 20ml of methanolic potassium hydroxide at 40ºC the contents left to be cooled, transferred to separatory funnel with 50ml normal hexane, shacked well and left to stand. The hydrocarbon layer taken and the column chromatography used to separate the extracts into aliphatic and aromatic hydrocarbons[14]. Column chromatography was organized by packing of silica (100 -200 mesh) 10 g, followed by alumina (100 -200 mesh) 10 g. Lastly, anhydrous sodium sulphate 1g was added to the surface to prevent disruption of the upper layer when pouring the solvent. After that, the extract was poured on the column head to get the aliphatic hydrocarbons, and then eluted with 25 ml of benzene to get the aromatic hydrocarbons. Furthermore, the fraction of aromatic hydrocarbons were concentrated using rotary evaporator and transported to a vial with the volume adjusted to 1ml using a stream of dry nitrogen. After that, about 1 µl of aromatic hydrocarbons extract taken for analysis by gas chromatography GC (allegiant capillary gas chromatography with flam ionization detector (FID)). The carrier gas was helium and the linear velocity was 1.5 mL min-1. Detector and injector temperatures are 350°C and 320°C. Initial temperatures of the silica capillary column were 70°C for 0 min for aromatic portion and 60°C for 4 min for aliphatic portion. Final temperatures of the silica capillary column were 300°C for aromatic portion and 280°C for aliphatic portion, last for 30min in 4 °C/min rate for both portions[15]. Hydrocarbons identification and quantification performed using Perkin- Elmer computing integrator model LC-100. PAHs sources whether it is of biogenic or anthropogenic origin indicated by the use of Carbon Preference Indices (CPI) and the Odd and Even n-alkane Predominance Index (OEPI)[15]. Pristane - C17, Phytane - C18 and Pristane: Phytane ratio were used as biomarkers for petroleum contaminants[15], and for approximation of the degree of degradation of bacteria[16].

5% phenyl Methyl silicone column (Agilent 19091J-101HP-5 contain dimensions to PAHs held at a temperature of 80°C for two minutes and then from 8°C /min. to 280°C for 12 min. Individual PAHs recognized depending on the mixed standard retention time, the standard was from Supelco, USA. The calibration curve was used to measure the concentration of PAHs compounds using matching standards. Three times more than the blank level is the limit quantity. Duplicated samples used for all groups.

Cancer risk evaluation of PAHs

Chronic exposure to PAHs in street dust is the focus for the health risk valuation in this study; it is related to the long-term influences on health, for example cancer or other chronic rather than acute toxic effects. The rate of inhalation is very important when evaluating the exposure doses. The doses of inhalation exposure of PAHs calculated by following Equation (1)[17]:

$$D = (RI \times C \times DE \times FE) / (EFP \times TA \times BW) \quad (1)$$

Where D is the dose of exposure, C is the concentration of PAHs; RI is the rate of intake value[18, 19]. DE the duration of exposure[20]. FE the frequency of exposure. EFP is the emission factor of particles; TA the time average and BW body weight, all are defined in table 1.

Table1: Factors of exposure and risk assessment.

Factor	Description	Units	Value		Reference
			Child	Adult	
D	dose of exposure	mg/kg/ day	Calculated	Calculated	
C	Concentration of PAHs	µg/g	Measured by GC-mass	Measured by GC-mass	
RI	rate of intake	m^3/ day	7.6	20	18, 19
DE	duration of exposure	years	6	24	20
FE	Frequency of exposure	days / year	180	180	
EFP	Emission factor of particles	m^3/kg	1.39×10^9	1.39×10^9	26
TA_{car}	Time average for carcinogen	Day	70 ×365	70 ×365	20
$TA_{non\text{-}car}$	Time average for non- carcinogen	Day	6 ×365	24 ×365	20
BW	Body weight	Kg	15	70	
REL	Reference exposure level	mg/kg	0.2	0.2	21
CSF	Cancer slope factor	mg/kg. day^{-1}	1.7	1.7	21
IR_{ing}	Ingestion rate	mg/day	100	50	20
IR_{inh}	Inhalation rate	m^3/day	7.6	20	26
AL	Average life span for PAHs	day	25550	25550	27
SA	Exposed surface area	Cm^2	2699	3950	20
AF	Dermal adherence factor	mg/cm^2.day	0.2	0.07	20
ABS	Dermal absorption fraction	-	0.13	0.13	20

Hazard quotient (HQ) used for expression of non-cancer risk calculated (as in Equation (2)) using exposure level divided by the reference exposure level (REL) for PAHs (equals to 0.2 mg/kg)[21]. To calculate exposure level or dose by equation (1) using TA time average of (6×365) day for children and (24×365) for adults, this is for non-carcinogens.

HQ = Exposure dose /REL (2)

Hazard index (HI) used for expression of non-cancer impacts on health calculated as the summation of HQs at different locations (as in Equation (3)):

$HI = HQ_1 + HQ_2 + HQ_3 + \ldots\ldots\ldots HQ_n$ (3)

The value of HQ less than or equal to 1 considered of no effects on health, while the values of HQ more than 1 consider a possibility of effects on health will happen.

The risk of exposure to PAHs from inhalation of street dust calculated by Equation (4):

Risk = D × CSF (4)

Where D is the dose of exposure calculated by equation (1) in mg/kg/day and CSF is Cancer slope factor of PAHs 1.7 (mg/kg. day^{-1}) according to[22].

United States Environmental Protection Agency (US EPA) regarded cancers risk from 10^{-6} to 10^{-4} normally satisfactory. Cancer hazards more than 10^{-4} (specifically, 1 in 10,000 persons) might not be regarded adequately protective[23].

Carcinogenic risk can be evaluated using Benzo (a) pyrene total potency equivalency (BaP TPE) concentration, which can be calculated by equation (5) for PAHs[24].

BaP TPE (µg/g) = C (µg/g) × TEF (5)

C is the concentration of PAHs measured in µg/g and TEF is the matching toxic equivalent factor for PAHs[25]. TEF value 0.001 for Naphthalene, Methylnaphthalyene, Acenaphthyene, Acenaphthene, Fluorene, Phenanthrene, Fluoranthene and Pyrene. Furthermore, TEF value 0.01 for Anthracene and Chrysene, 0.1 for Benzo(a) anthracene, Benzo (b) fluoranthene and Benzo (k) fluoranthene, 1 for Benzo (a) pyrene and Benzo(g, h, i) perylene**.** After that, the incremental excess lifetime cancer risk IELCR that is the probability of developing cancer as the result of exposure to a specific carcinogen were calculated using the following equations:

$$\text{IELCR ingestion} = \frac{\sum \text{BaP TPE} \times \left(\text{CSF ing} \times \sqrt[3]{\left(\frac{BW}{70}\right)}\right) \times IR \text{ ing} \times FE \times DE}{\text{BW} \times \text{AL} \times 10^6} \quad (6)$$

$$\text{IELCR inhalation} = \frac{\sum \text{BaP TPE} \times \left(CSF\ inh \times \sqrt[3]{\left(\frac{BW}{70}\right)}\right) \times IR \text{ inh} \times FE \times DE}{\text{BW} \times \text{AL} \times \text{E}FP} \quad (7)$$

$$\text{IELCR dermal} = \frac{\sum \text{BaP TPE} \times \left(CSF\ der \times \sqrt[3]{\left(\frac{BW}{70}\right)}\right) \times SA \times AF \times ABS \times FE \times DE}{\text{BW} \times \text{AL} \times 10^6} \quad (8)$$

$$\text{Carcinogenic Risk} = \text{IELCR}_{\text{ingestion}} + \text{IELCR}_{\text{inhalation}} + \text{ELCR}_{\text{dermal}} \quad (9)$$

RESULTS AND DISCUSSION

Seventeen compounds of PAHs were identified in street dust samples in the present study in Al- Shafi, Al-Qurna, Al Seeba, Abu Kaseeb, Al- Fao and Al Burjessya locations in the residential areas in city of Basrah nearby to oil refineries and petrochemical industries areas. These compounds include two types of PAHs. The first type includes Naphthalene, Methylnaphthalyene, Acenaphthyene, Acenaphthene, Fluorene and Phenanthrene, which are of low molecular weight (light) compounds, containing 2-3 fused aromatic rings. The second type includes Anthracene, Fluoranthene, Pyrene, Chrysene, Benzo(a)anthracene, Benzo (b) fluoranthene, Benzo (k) fluoranthene, Benzo (a) pyrene and Benzo(g, h, i) perylene, these are of high molecular weight (heavy) compounds, containing four or more fused aromatic rings.

The total PAHs concentrations in street dust samples at six stations were measured using GC/MS, the higher concentration was 6.77E+03 µg/g in Al-Shafi neer to Majnoon oil refinery. The next higher concentrations were 5.18E+03 µg/ g in Al-Qurna, 4.99E+03 µg/g in Al-Seeba, 4.49E+03 µg/g in Abu Kaseeb, 4.14E+03 µg/g in Al-Fao and 3.52E+03 µg/g in Al Burjessya. As illustrated in table 2.

Table 2: Total PAHs concentrations in Basrah streets dust samples at six stations measured using gas chromatography/mass spectrometry (GC/MS).

Name	Aromatic rings	Amount [ug/g]							%
		Al- Shafi	Al-Qurna	Al- Seeba	Abu Al-Kaseeb	Al- Fao	Al-Burjessya	Total	
Naphthalene	2	2.80E+01	0.00E+00	2.66E+01	0.00E+00	1.88E+01	2.10E+01	9.45E+01	0.32
1-Methylnaphthalyene	2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.89E+01	3.89E+01	0.13
Acenaphthylene	3	2.82E+01	2.31E+01	2.74E+01	2.28E+01	1.73E+01	7.72E+01	1.96E+02	0.67
Acenaphthene	3	7.23E+01	6.68E+01	4.20E+01	4.36E+01	4.50E+01	3.26E+01	3.02E+02	1.04
Fluorene	3	2.89E+03	2.52E+03	1.66E+03	1.71E+03	1.76E+03	1.42E+03	1.20E+04	**41.10**
Phenanthrene	3	6.22E+02	7.87E+01	4.79E+01	3.61E+02	5.54E+01	3.55E+01	1.20E+03	4.12
Anthracene	3	2.33E+03	1.93E+03	1.35E+03	1.40E+03	1.41E+03	1.15E+03	9.57E+03	**32.89**
Fluoranthene	4	7.89E+01	7.24E+01	6.02E+01	7.41E+01	5.96E+01	4.61E+01	3.91E+02	1.35
Pyrene	4	4.32E+01	2.20E+01	7.63E+01	1.27E+01	1.86E+01	3.13E+01	2.04E+02	0.70
Chrysene	4	1.65E+02	1.11E+02	2.37E+02	8.91E+01	1.11E+02	1.82E+02	8.97E+02	3.08
Benzo(a) anthracene	4	6.45E+01	6.81E+01	7.32E+01	9.80E+01	6.57E+01	6.18E+01	4.31E+02	1.48
Benzo(b) fluoranthene	5	2.05E+02	1.36E+02	3.47E+02	1.83E+02	2.11E+02	2.03E+02	1.29E+03	4.42
Benzo(k) fluoranthene	5	3.28E+01	1.31E+01	6.78E+01	1.93E+01	2.91E+01	1.56E+01	1.78E+02	0.61
Benzo (a) pyrene	5	1.19E+02	8.42E+01	2.75E+02	1.41E+02	1.31E+02	7.53E+01	8.26E+02	2.84
Indeno(1,2,3CD)Pyrene +Dibenz(a,h)anthracene	6	2.48E+01	0.00E+00	2.06E+02	8.06E+01	8.36E+01	4.89E+01	4.44E+02	1.52
Benzo(g,h,i) perylene	6	7.38E+01	5.59E+01	4.91E+02	2.55E+02	1.23E+02	8.38E+01	1.08E+03	3.72
Total PAH		6.77E+03	5.18E+03	4.99E+03	4.49E+03	4.14E+03	3.52E+03	2.91E+04	100
Low molecular weight	2-3	5.97E+03	4.62E+03	3.15E+03	3.54E+03	3.31E+03	2.77E+03	2.34E+04	80.28
High molecular weight	4-6	8.08E+02	5.64E+02	1.83E+03	9.53E+02	8.33E+02	7.48E+02	5.74E+03	19.72
Combustion PAHs		7.09E+02	5.08E+02	1.14E+03	6.18E+02	6.27E+02	6.15E+02	4.21E+03	14.48
Carcinogenic PAHs		7.14E+02	4.69E+02	1.72E+03	8.66E+02	7.74E+02	6.91E+02	5.24E+03	18.00
Non carcinogenic PAHs		6.06E+03	4.72E+03	3.26E+03	3.63E+03	3.37E+03	2.83E+03	2.39E+04	82.00

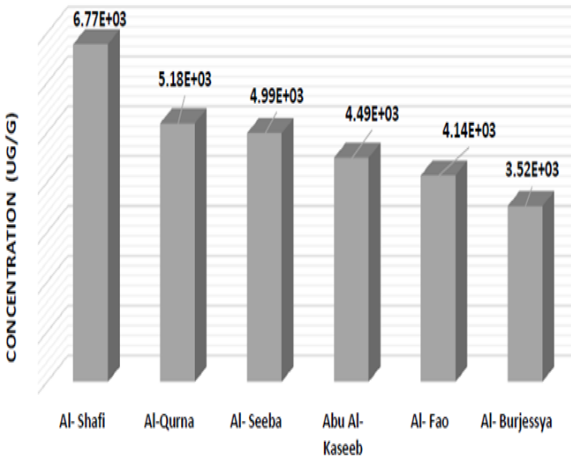

Fig. 2: Regional variations in total PAHs levels (μg/g) in different Basrah streets dust.

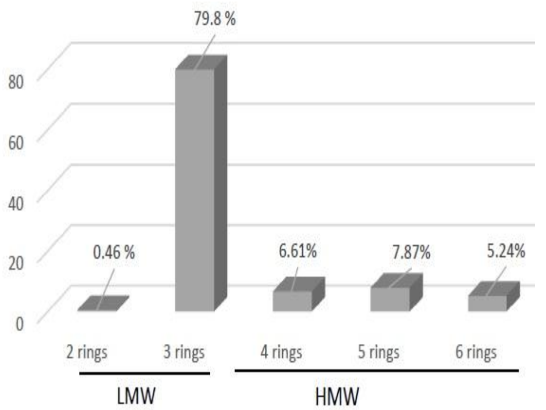

Fig. 3: Percentage distribution of individual PAHs from total PAHs compounds in different Basrah streets dust. LMW (low molecular weight) and HMW (high molecular weight).

The seventeen PAHs that classified by US EPA as important contaminants were detected in the collected samples, low molecular weight PAHs containing 3 fused aromatic rings were the main PAHs with a percentage of 79.82%. Followed by the high molecular weight 5 rings PAHs percentage of 7.9%, 4 rings PAHs percentage of 6.6%, 6 rings PAHs percentage of 5.4% and the least percentage 0.5% of 2 rings PAHs, as shown in table 2 and figure 2. The results revealed that the pattern of PAHs compounds levels is similar in all of the collected samples. However, these PAHs compounds levels were from different sources such as industrial or traffic activities at different sites.

The summation of Fluoranthene, Pyrene, Chrysene, Benzo(a)anthracene, Benzo (b) fluoranthene, Benzo (k) fluoranthene and Benzo (a) pyrene concentrations represent a combustion PAHs[28] makes up 14.5% of the total PAHs in the tested samples of Basrah street dust. Carcinogenetic PAHs are the summation of Naphthalene, Chrysene, Benzo (a) anthracene, Benzo (b) fluoranthene, Benzo (k) fluoranthene, Benzo (a) pyrene and Dibenzo(a,h) anthracene concentrations, makes up 18% of the total PAHs in the tested samples of Basrah street dust. Non-carcinogenic PAHs makes up 82% of the total PAHs in the tested samples of Basrah street dust (figure 2).

The results of this study revealed that the higher percentage of PAHs types are the 3 ring PAHs compounds, Fluorene (41%) and Anthracene (33%), as illustrated in table 2. These results are in cope with previous study on sediments, in Basrah[29].

Health Risk Evaluation

The health risk evaluation focused on the total PAHs in the street dust indicated that People living near to risky areas might exposed to risk by inhalation of air having PAHs compounds. However, it is unknown how fast wholly lungs absorb PAHs compounds.

Exposure doses were 6.47E-07 to 1.24E-06 μg/g day for child non-carcinogen and 3.65E-07 to 7.02E-07 μg/g day for adult non-carcinogen. The suggestion of EPA, if the body of human absorbs daily 0.3ug/g anthracene, 0.06ug/g acenaphthene, 0.04 μg/g of fluorine or fluoranthene and 0.03 μg/g of pyrene of the body weight, this causes no adverse effects on health[30]. The Exposed daily doses verified in this study were less than the EPA suggested safe daily doses absorbed by human body. Furthermore, these daily doses less than the doses in United States, which are 3 μg/g day[31].

HQ and HI were used to express the non-cancer hazard at different sites. HQ values less than or equal to one indicates no effects on health, but the HQ values more than one indicates adverse effect possibility on the health. In the current study, the HQ calculated values were lower than one in all sites, revealed that there were no hazard on health from non-carcinogens, as illustrated in table 3.

The cancer risk from inhalation of PAHs compound valuated as 5.55E-08 to 1.07E-07 for child Carcinogen and 1.25E-07 to 2.41E-07 for adult Carcinogen. The results of this study revealed that the cancer risk levels are within the harmless levels, it is less than 10^{-4} (specifically, 1 in 10,000 persons) [23].

Table 3: Health risk evaluation of the total PAHs level in the dust of Basrah streets

		Al- Shafi	Al-Qurna	Al- Seeba	Abu Al-Kaseeb	Al- Fao	Al-Burjessya	Total	HI
Dose (µg/g day) Noncarcinogen	Child	1.24E-06	9.53E-07	9.16E-07	8.25E-07	7.61E-07	6.47E-07	5.34E-06	
	Adult	7.02E-07	5.37E-07	5.17E-07	4.65E-07	4.29E-07	3.65E-07	3.02E-06	
Dose (µg/g day) Carcinogen	Child	1.07E-07	8.16E-08	7.85E-08	7.07E-08	6.52E-08	5.55E-08	4.59E-07	
	Adult	2.41E-07	1.84E-07	1.77E-07	1.60E-07	1.47E-07	1.25E-07	1.03E-06	
HQ	Child	6.22E-06	4.76E-06	4.58E-06	4.13E-06	2.15E-06	3.24E-06	2.51E-05	2.67E-05
	Adult	3.51E-06	2.69E-06	2.58E-06	2.33E-06	3.24E-06	1.82E-06	1.62E-05	1.51E-05
Risk	Child	2.12E-06	1.62E-06	1.56E-06	1.40E-06	1.29E-06	1.10E-06	9.09E-06	
	Adult	1.19E-06	9.13E-07	8.78E-07	7.91E-07	7.29E-07	6.20E-07	5.12E-06	

Incremental excess lifetime cancer risk IELCR related to PAHs exposure from Basrah street dusts was estimated by the use of USEPA standards (for resident's model)[23]. Human are exposed to street dust through ingestion pathway or inhalation pathway or by dermal contacts of dust. So, the carcinogenic hazard can be calculated by adding the risks estimated from the three above-mentioned pathways to get a total risk.

Carcinogenic risk from ingestion and dermal pathways in all samples were about 10^{-4}, while the Carcinogenic risk from inhalation was 10^{-8}, which is about two times less than that of dermal contact and ingestion (table 4). Then, ingestion and dermal contact pathways are the main exposure routes to PAHs. These results are in cope with another study showed that both ingestion and dermal contact contribute significantly to carcinogenic effect[32].

Table 4: Incremental excess lifetime cancer risk IELCR

	Child	Adult
***IELCR** ingestion*	6.48E-04	4.64E-04
***IELCR** inhalation*	3.54E-08	1.34E-07
***IELCR** dermal*	4.55E-04	3.34E-04
Carcinogenic Risk	1.10E-03	7.98E-04

The risk on children more than adults and the young children are the more sensitive because of their activity to their mouth and the polluted dust can be swallowed easily[33].

The results of this study revealed that street dust in Basrah contains PAHs concentrations indicated contribution of industrial and traffic activities. However, such studies are insufficient in Basrah, a city experience unplanned development, increased traffic, combustion of fuel and construction.

Conclusion

The total PAHs concentrations in street dust samples at six stations were measured and the higher concentration was 6.77E+03 µg/g in Al-Shafi near to Majnoon oil refinery and the lower concentration was 3.52E+03 µg/g in Al Burjessya in the street dust of Basrah.

Low molecular weight PAHs containing 3 fused aromatic rings were the main PAHs with a percentage of 79.82% and the least percentage 0.5% of 2 rings PAHs. The pattern of PAHs compounds levels is similar in all of the collected samples.

Exposure doses ranges from 6.47E-07 to 1.24E-06 µg/g day for child non-carcinogen and 3.65E-07 to 7.02E-07 µg/g day for adult non-carcinogen. The Exposed daily doses verified in this study were less than the EPA suggested safe daily doses absorbed by human body.

HQ calculated values were lower than one in all sites, revealed that there were no hazard on health from non-carcinogens.

The cancer risk from inhalation of PAHs compound valuated as 5.55E-08 to 1.07E-07 for child Carcinogen and 1.25E-07 to 2.41E-07 for adult Carcinogen. The results of this study revealed that the cancer risk levels are within the harmless levels, it is less than 10^{-4}.

Carcinogenic risk from ingestion and dermal pathways in all samples were about 10^{-4}, while the Carcinogenic risk from inhalation was 10^{-8}, which is about two times less than that of dermal contact and ingestion

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Author's Contribution

The authors have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

Ethics Statement

Institutional Ethical Committee accepted the research.

Conflicts Of Interest

The authors declare that they have no conflicts of interest.

Data Availability Statement

All datasets generated or analyzed during this study are included in the manuscript and/or the Supplementary Files.

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تقييم المخاطر الصحية للهيدروكربونات العطرية السامة متعددة الحلقات (PAHs) في غبار شوارع البصرة، العراق

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تعتبر جزيئات الغبار على سطح الشوارع الحضرية من بين أكبر المصادر المهمة لتلوث الأجواء الحضرية في شكل الهباء الجوي الناعم. هدفت هذه الدراسة إلى تحديد تركيز الهيدروكربونات العطرية متعددة الحلقات في عينات الغبار التي تم جمعها من شوارع مدينة البصرة لتقييم مخاطرها المحتملة على النظام البيئي، وخاصة خطر الإصابة بالسرطان من ملامسة الجلد والاستنشاق والابتلاع. تم قياس الهيدروكربونات العطرية متعددة الحلقات في عينات غبار الشوارع من الشافي والقرنة والسيبة وأبي الخصيب والفاو والبرجسية باستخدام كروماتوجرافيا الغاز / مطياف الكتلة (GC / MS) في البصرة. وكانت اهم الملوثات المهمة للهيدروكربونات العطرية متعددة الحلقات المصنفة من قبل وكالة حماية البيئة الأمريكية المكتشفة في العينات هي الهيدروكربونات العطرية ذات الثلاث حلقات(٧٩.٨٢%) ، تليها ذات الخمس حلقات (٧.٩%)، ثم الاربعة حلقات (٦.٦%)، ثم ذات الستة حلقات(٥.٤%) واخرها ذات الحلقتين من الهيدروكربونات العطرية متعددة الحلقات (٠.٥%). تراوحت جرعات التعرض من 6.47 E-07 ug/g day إلى 1.24E-06 ug/g day للأطفال غير المسرطنة و 3.65E-07 إلى 7.02E-07 ug/g day للبالغين غير المسرطنة. وكانت جرعات التعرض أقل من الجرعات اليومية الآمنة التي اقترحتها وكالة حماية البيئة.

وكانت قيم (HQ) حاصل الخطر أقل من واحد في جميع المواقع ، وهذا يؤكد عدم وجود خطر على الصحة من المواد غير المسرطنة. وكانت مخاطر الإصابة بالسرطان من الاستنشاق تتراوح من 5.55 E-08 إلى 1.07 E-07 للمواد المسرطنة للأطفال **و** 1.25E-07 إلى 2.41E-07 للمواد المسرطنة للكبار وهو أقل **من** 10^{-4} ضمن المستويات غير المؤذية. مخاطر الإصابة بالسرطان من الاستنشاق أقل مرتين من مخاطر الجلد والابتلاع.