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Polycyclic Aromatic Hydrocarbon (PAH) Pollution in Soil and Groundwater and Its Association with Blood Biomarkers among Workers in Dura, Nahrawan, and Taji Industrial in Baghdad at 2025.

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Abstract
Background: Atmospheric PAHs mainly originate from the inefficient combustion of organic compounds commonly employed in industrial sectors. In Baghdad, ongoing industrial expansion has led to elevated pollution levels, which may result in increased risks of carcinogenicity and genetic alterations among the population. Such impacts are more evident in residential areas adjacent to industrial facilities. **Objectives:** The objective of this research was to measure the presence of five PAH compounds in soil and groundwater samples collected from three major industrial areas in Baghdad, while simultaneously examining occupational exposure through serum analysis of the workers. **Materials and Methods:** Sampling of soil and groundwater was carried out at three industrial locations, including the Dura Refinery, brick factories in Nahrawan, and asphalt plants in Taji. Serum samples were collected from 30 occupationally exposed individuals. The identification and quantification of five target PAHs were performed using HPLC, and inter-compound associations were assessed using Pearson correlation analysis. **Results:** Industrial soils, especially those with asphalt and brick factories, had very high levels of PAHs. However, it was not easy to see that these compounds were getting into the groundwater. The presence of all five PAH compounds in the workers' blood indicates direct occupational exposure. Naphthalene (r=0.981) and chrysin (r=0.765) had the strongest links between soil contamination and blood serum. **Conclusion:** The results show a clear connection between polycyclic aromatic hydrocarbon (PAH) pollution and occupational exposure in industrial areas in Baghdad. This indicates the presence of carcinogenic compounds in the blood plasma of workers, which poses a significant health risk and requires effective environmental monitoring and strict enforcement of health and safety regulations in the workplace.
Keywords; Polycyclic Aromatic Hydrocarbons" occupational exposure" biomonitoring" industrial pollution" blood biomarkers" Baghdad.

1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a group of organic pollutants which are abundant in nature, and they generally contain two or more aromatic rings combined. Primarily, they result from thermochemical reactions that arise after incomplete combustion of organic carbon sources (e.g., coal, petroleum, gas, wood) [1]. Due to the development of industrialization and urbanization, they have been extensively distributed in the environment and demographic elements and are ubiquitously found in many environmental compartments, such as air, water, and soil [2]. They are resistant to the environment and have a long half-life due to their hydrophobicity and chemical inertness, consequently enhancing exposure in humans.

The greatest health hazard posed by PAHs is to cause genetic mutations and cancer. The International Agency for Research on Cancer (IARC) has classified some of these compounds as possible or known human carcinogens, with benzo(a)pyrene being classified as Group 1 (human carcinogen) due to its potential adverse health effects [3]. Exposure to these compounds is mainly through inhalation and ingestion in food and water, as well as dermal uptake [4]. Occupational exposure is one of the most hazardous types of exposure in industrial areas such as oil refining, the asphalt industry, coking production, and metal smelting plants this is because workers are exposed to higher concentrations for longer periods compared to the general public [5].

Measured concentrations of chemical pollution in Human Biomonitoring (HBM) Data related to the presence of chemical pollutants inside the human body. Instead of being exclusively based on assessing pollutants in the external environment, biomonitoring permits measurements of the parent compound or its metabolites in biological tissues/fluids (e.g., blood/urine) [6]. The determination in blood serum offers a better estimate for the whole-body burden, as it represents integrated exposure through all manners of exposure (inhalation, dermal, and ingestion) [7].

There are many factories that have been working for a long time in IRAQ, especially in BAGHDAD, creating fearfulness against the effect of pollution on the environment and health workers and residents around it. Although some research has been conducted on quantifying pollution levels in the environment in different areas, little is directly known about the association between exposure to PAH and biomarkers among those people with occupational exposure. Accordingly, the present study has two main goals: 1) to estimate the levels of contamination of some PAHs in soil and groundwater around selected strategic industrial zones in Baghdad (three of major concern), and 2) to investigate possible relationships between this environmental pollution, on one hand, and concentrations of these five compounds measured in the blood serum of workers active within those domains.

2. Materials and Methods

2.1. Research Areas

The three main industrial sites located inside Baghdad, characterized by high intensity of industrial activities and potential for PAH pollution:

Dura Refinery: A major Iraq refinery is thought to be a potential contributor of PAH emissions from the refining of Petroleum.

Asphalt plants: located in the Taji region, use heat to melt and blend bitumen, resulting in significant PAH vapor emissions.

Nahrawan Brick Factories: The Nahrawan brick factories consume heavy fuel in the kilns, which results in uncompleted combustion and high emissions of pollutants such as PAHs.

2.2. Sample Collection

There were two types of samples: environmental (soil and water) and from organisms (blood).

Environmental Sampling: Nine soil samples (three from each industrial district) were collected from 0-15 cm. In both areas, it was obtained from Nine ground water sources wells that were 9–12 m deep.

Biological Samples: Blood samples were collected from 30 voluntary workers (10 workers in each industrial area). Extraction of workers working for 5 or more years from the included companies. Whole blood was collected in special tubes, and serum was separated for analysis.

2.3. Analysis and Extraction of polycyclic aromatic hydrocarbons (PAHs).

The chosen PAHs for the study were naphthalene, chrysene, benzo(a)pyrene (BAP), benzo(b)fluoranthene, and benzo(a)anthracene. They were chosen because they are important and could cause cancer. We used a solvent mixture of n-hexane and acetone (1:1) to extract soil and water samples (1 g or 400 mL, respectively). SPE was used to clean and concentrate blood serum samples. The High-Performance Liquid Chromatograph (HPLC) with a photo-diode array detector at 247 nm was used to find out how much (PAH) was in each sample. We used standard curves for each compound to figure out how much of each filtered compound was in the solution.

2.4. Statistical Analysis

The Python software, which includes matplotlib and pandas, is used for data analysis and graphing presentation. The concentrations of (PAHs) were expressed as mean, standard deviation, and minimum and maximum values in all samples. For each field, the correlation between average concentrations in soil and workers' blood was tested with the Pearson coefficient. The level of statistical significance was fixed at $p < 0.05$.

3: Results and Discussion

3.1: Soil and Water Contamination with PAHs

Results analysis the environmental analyses showed that soil of the three industrial areas investigated was widely contaminated with PAHs and significantly differed among the sampling sites. The average total concentration of the five compounds in soil was highest for asphalt factories and followed by brick factories, as well as Dura Refinery (Table 1 and Figure 1). E.g., the average naphthalene content was (166.6 µg/L) in soil from the asphalt factory (considerably higher than the average of Dura Refinery (59.8 µg/L)). This trend is applicable to the majority of other substances, which suggests that industrial activities are essential factors determining both the scale and form of pollution. The higher magnitudes in the asphalt and brick industries may be related to the direct and Uncontaminated burning of heavy fuel and bitumen.

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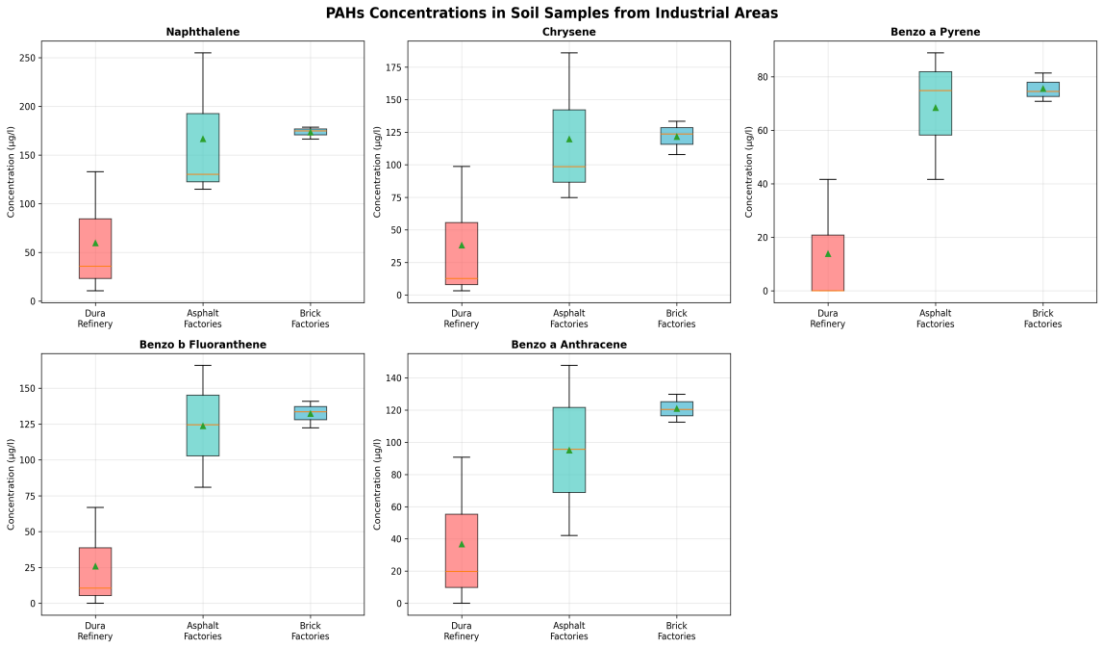

Figure 1: The soil samples collected from Dura Refinery, asphalt factories, and brick factories were analyzed for their content of five PAH compounds, which are shown.

Table 1: Descriptive Statistics of PAH Concentrations in Soil (µg/L)

Location	Naphthalene Mean ± SD	Chrysene Mean ± SD	Benzo(a)Pyrene Mean ± SD	Benzo(b)Fluoranthene Mean ± SD	Benzo(a)Anthracene Mean ± SD
Asphalt Factories	166.6 ± 76.8	119.7 ± 56.2	68.4 ± 24.7	123.8 ± 42.8	95.2 ± 52.9
-Brick Factories	173.3 ± 6.2	121.6 ± 12.9	75.6 ± 5.7	132.3 ± 9.4	120.9 ± 8.6
Dura Refinery	59.8 ± 64.6	38.2 ± 48.8	13.9 ± 24.0	25.8 ± 37.5	36.8 ± 47.8

In contrast, groundwater contamination was much lower than soil contamination, with some high molecular weights compounds such as benzo(a)pyrene not detected in most water samples (Table 2). The findings demonstrate that soil functions as the main storage area for these pollutants, while their transfer to groundwater occurs at a slow rate because they resist water absorption and stick to soil particles [8]. The existence of specific substances in groundwater creates a continuing danger to public health.

Table 2: Descriptive Statistics of PAH Concentrations in Groundwater (µg/L)

Location	Naphthalene Mean ± SD	Chrysene Mean ± SD	Benzo(a)Pyrene Mean ± SD	Benzo(b)Fluoranthene Mean ± SD	Benzo(a)Anthracene Mean ± SD
Asphalt Factories	0.0 ± 0.0	10.3 ± 1.4	0.0 ± 0.0	0.0 ± 0.0	7.7 ± 2.0
Brick Factories	4.7 ± 0.6	3.2 ± 0.5	0.0 ± 0.0	0.0 ± 0.0	2.7 ± 0.5
Dura Refinery	8.6 ± 15.0	3.3 ± 3.5	4.2 ± 7.3	5.3 ± 9.2	2.6 ± 3.0

3.2. PAH Concentrations in Worker Blood

More alarming was the presence of all PAH compounds in blood serums of workers from all industrial areas, which proved the direct impact on humans. Blood patterns (Figure 2) broadly mirror soil contamination patterns. For instance, the workers from asphalt plants had the highest naphthalene in blood as well (1.06 ppb), and about 2 years before had received the higher soil levels of this contaminant at that site. As depicted in (Figure 3), detection rates were high, and at least one of the PAHs was detected in all workers from the brick factory (100%), followed by asphalt refinery workers (80%) and Dura Refinery ones (70%) (Table 3). This corroborates that OA is not an occasional encounter but repeated and consistent exposure.

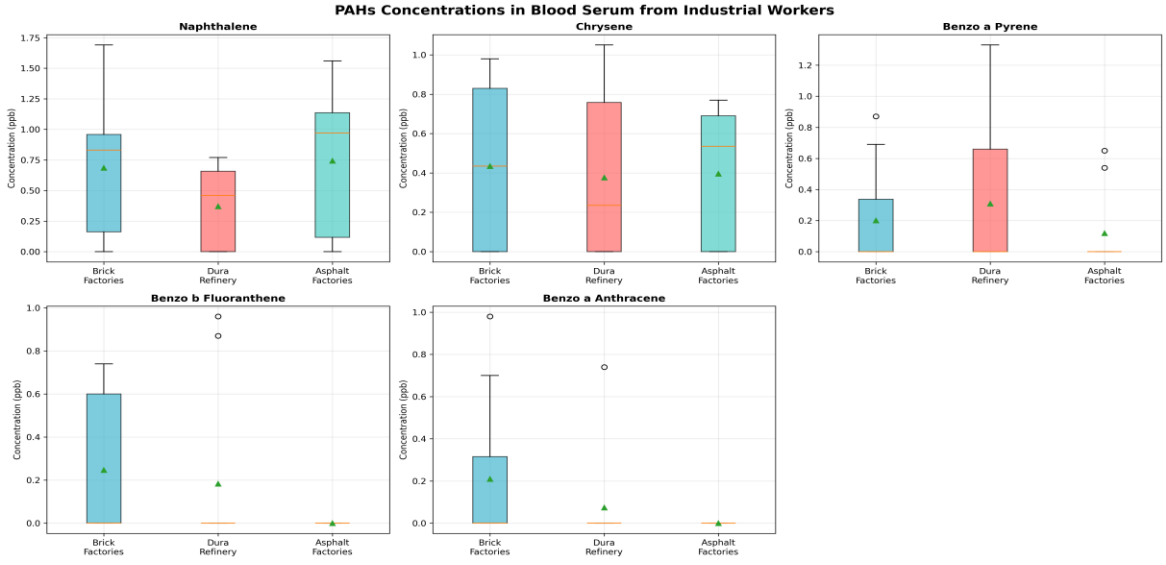

Figure 2: A comparison of the levels of five PAH compounds in the blood serum of workers from three different industrial areas.

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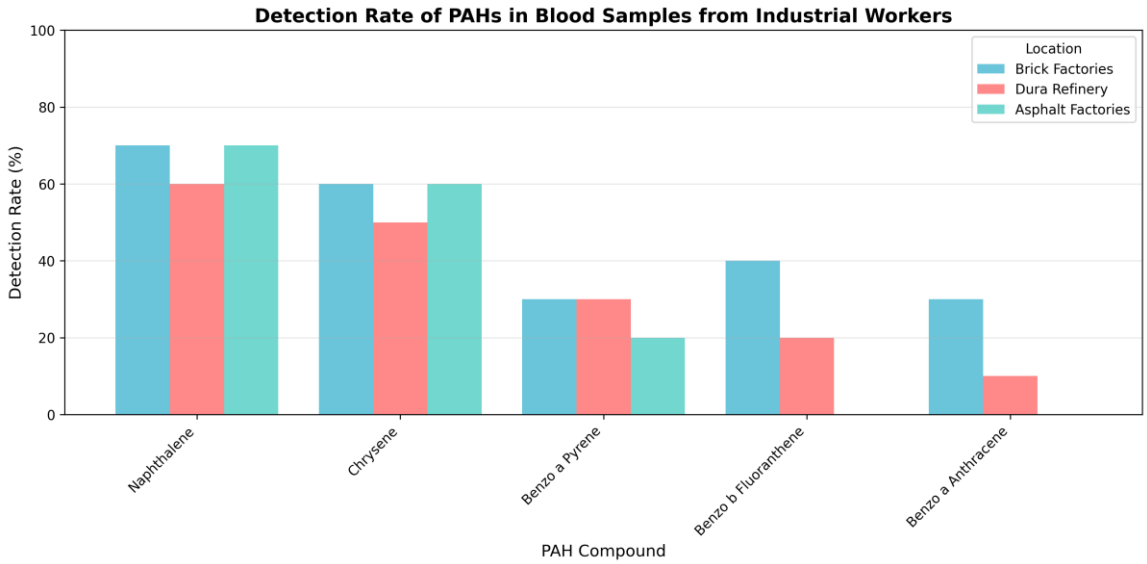

Figure 3: The percentage of blood samples from each industrial site that contained each PAH compound.

Table 3: Mean PAH Concentrations in Blood Samples (ppb)

Location	Naphthalene Mean	Chrysene Mean	Benzo(a)Pyrene Mean	Detection Rate (%)
Brick Factories	0.98	0.59	0.67	100.0
Dura Refinery	0.62	0.59	1.03	70.0
Asphalt Factories	1.06	0.60	0.60	80.0

3.3. Relationship between Soil Contamination and Occupational Exposure

To assess the extent to which soil contamination contributes directly to exposure of workers, the relation was examined between average levels of compounds in the soil and average blood levels at each site. The results also indicated that a strong and statistically highly significant correlation existed for naphthalene (r = 0.981) and chrysene (r = 0.765), respectively, as illustrated in (Figure 4). This significant correlation suggests that contaminated soil in the workplace is a primary source of worker exposure to these two compounds, presumably through inhalation of contaminated soil dust and dermal absorption. This result is in line with the above-mentioned reports, verifying that inhalation and dermal access to PAH are the main routes of occupational exposure [5].

In contrast, benzo(a)pyrene was inversely correlated, and the correlations with the other compounds were less strong. This discrepancy might be due to the different metabolism rates of each compound in the body, variations in other indirect ways of exposure (i.e., passive smoking), or statistical issues associated with correlation analysis, considering that there were only a limited number of stations studied here (three). Nevertheless, high positive correlations were found for naphthalene and chrysene, suggesting a clear association between polluted workplaces and the levels of deposited pollutants within workers.

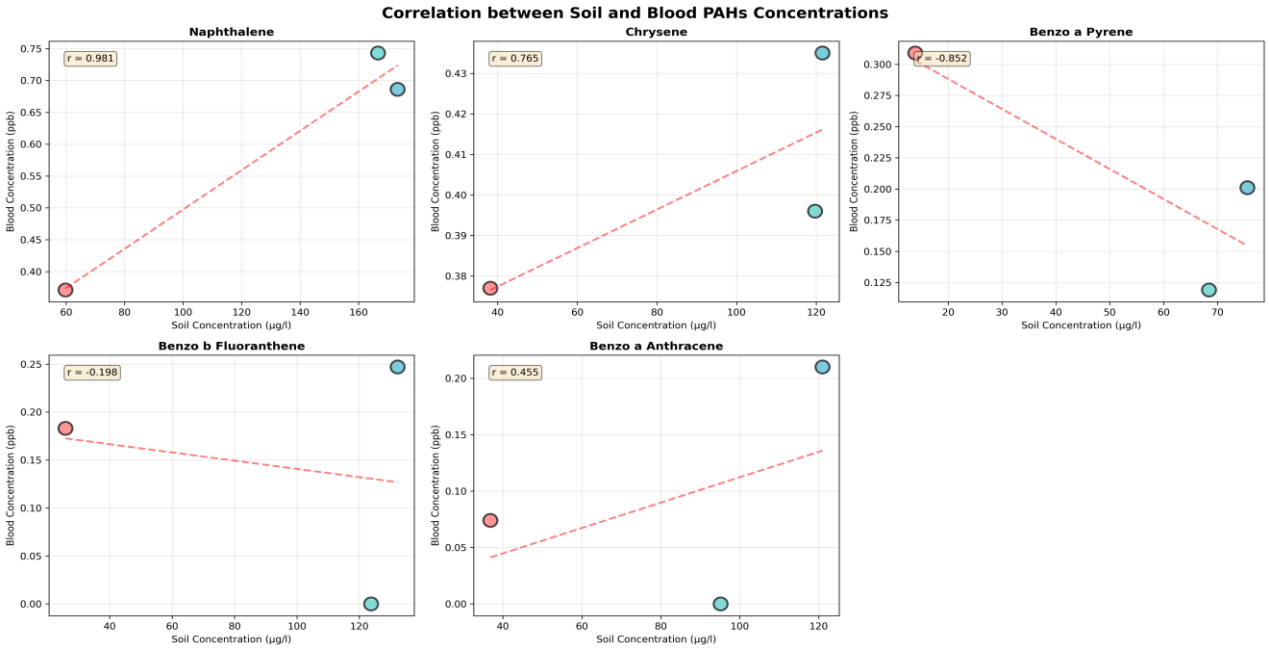

Figure 4: A graph that shows how the average amount of each compound in soil (x-axis) and blood (y-axis) is related across three industrial sites. r is the Pearson correlation coefficient.

3.4. Health Risk Implications

The presence of PAHs in quantifiable concentrations in the blood of workers can be perceived as a public health concern. The IARC has classified many of the PAHs detected here, including benzo(a)pyrene, as group 1 carcinogens [3]. Prolonged exposure to these compounds can lead to risk of lung and skin cancer, heart disease, and reproductive disorders [9]. The high correlation between environmental contamination and blood levels indicate ongoing exposure for workers that potentially could bio accumulate gradually.

It is well documented from previous studies that people working at industrial jobsites are exposed to PAHs and develop DNA adducts and oxidative stress, leading potentially to carcinogenesis [10]. The detection rates found in the present study (70–100%) are much higher than those reported within the general population studies, indicating that the industrial workers are a high-risk population, which should be intervened as soon as possible.

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3.5. Comparing with International Standards.

Several violations of international soil PAH concentration levels were found when comparing to the PAH concentrations in the studied profile. The USEPA has developed soil screening levels for residential settings and defined such a screening level of 0.1 mg/kg (or 100 µg/g) (in our units) for benzo(a)pyrene [11]. The levels in asphalt and brick factories are a minimum of 7-9 times higher than this limit, which would be classified here as serious pollution. Similarly, the levels of PAHs in groundwater, which is less than soil, were higher than drinking water standards in some cases, especially naphthalene and chrysene. If we compare PAH concentrations in the soils tested here with international standards, several surpassing's are observed. The US Environmental Protection Agency (USEPA) has developed soil screening levels (SSLs) for residential settings, using a value of 0.1 mg/kg (i.e., ~0.1 µg/L expressed in our results unit) as the target concentration for benzo(a)pyrene [11]. The detected concentration of in asphalting and brick factories, which is significantly higher than the allowed limit, demonstrates the very serious pollution. In a similar way, PAH levels measured in groundwater are also below those found in soil but higher than drinking water limit values for some components, especially naphthalene and chrysene. However, the levels of PAHs in the blood of workers. those of our industrial workers, therefore suggesting an increased occupational exposure.

4. Conclusion

This research found an unambiguous relationship between the contamination of the environment with PAHs in the industrial area and the occupational exposure of occupationally involved humans in both studied sites. The presence of these toxic compounds in the blood of workers reflected a landscape heavily contaminated with them, especially in asphalt and tile plants, indicating high levels of contamination in soil. The significant positive relationships between the concentrations of some compounds in soil and blood imply that working in a contaminated environment is a serious health hazard.

This is, to our knowledge, the first time in Iraq such environmental vs. biological measurements of PAHs have been compared quantitatively within an industrial work situation. The results highlight the urgent need for strict preventive and control measures. We recommend the following:

1. Factory-level decarb technologies, such as cleaner fuels and combustion efficiencies.
2. Monitoring of pollutant levels in soil and air (at the industrial facilities, for example).
3. Workers are given proper PPE to protect them from harmful substances like lead or asbestos and trained on how to use it.
4. Incorporating periodically refreshed biomonitoring measurements (e.g., involving blood tests) in occupational health programs aiming for the rapid detection of exposure and confirmation of the effectiveness of preventive measures.
5. The establishment of occupational exposure limits (OEL) for PAHs in Iraqi workplaces adheres to international regulations and standards.
6. Implementation of medical surveillance programs for workers, including regular health screening and cancer detection.

References

1. Madaki, K. A., Bawa, U., & Rabi'u, H. M. (2024). Polycylic Aromatic Hydrocsbons as hazardous pollutant: Sources, impact on the environment and human health, monitoring and preventive strategies. *Dutse Journal of Pure and Applied Sciences*, *10*(4a), 9-15.
2. Cao, H., Chao, S., Qiao, L., Jiang, Y., Zeng, X., & Fan, X. (2017). Urbanization-related changes in soil PAHs and potential health risks of emission sources in a township in Southern Jiangsu, China. *Science of the Total Environment*, *575*, 692-700.
3. Ukpebor, J. E., Omoruyi, C. I., Omonmhenle, S. I., Imhontu, M., Oghoje, S. U., Isara, A. R., & Ukpebor, E. E. (2023). Concentrations of PAHs from urban and rural areas in Southern Nigeria using polyurethane foams (PUF) passive samplers: Health impact and cancer risk assessment. *Scientific African*, *22*, e01976.
4. Montano, L., Baldini, G. M., Piscopo, M., Liguori, G., Lombardi, R., Ricciardi, M., ... & Motta, O. (2025). Polycyclic Aromatic Hydrocarbons (PAHs) in the Environment: Occupational Exposure, Health Risks and Fertility Implications. *Toxics*, *13*(3), 151.
5. Louro, H., Gomes, B. C., Saber, A. T., Iamiceli, A. L., Göen, T., Jones, K., ... & Silva, M. J. (2022). The use of human biomonitoring to assess occupational exposure to PAHs in Europe: a comprehensive review. *Toxics*, *10*(8), 480.
6. Styszko, K., Pamuła, J., Pac, A., & Sochacka-Tatara, E. (2023). Biomarkers for polycyclic aromatic hydrocarbons in human excreta: recent advances in analytical techniques—a review. *Environmental Geochemistry and Health*, *45*(10), 7099-7113.
7. Al-Battawi, S., Latif, M. T., How, V., Thilakavathy, K., Abd Hamid, H. H., Hameed, S., & Ho, Y. B. (2024). Polycyclic aromatic hydrocarbons (PAHs) in blood serum of adults living in high and low-traffic volume areas in Malaysia: A comparative cross-sectional study. *Environmental Research*, *261*, 119744..
8. Cui, Z., Wang, Y., Du, L., & Yu, Y. (2022). Contamination level, sources, and health risk of polycyclic aromatic hydrocarbons in suburban vegetable field soils of Changchun, Northeast China. *Scientific reports*, *12*(1), 11301.
9. Du, T., Shen, X., & Zhan, R. (2024). Association of mixed polycyclic aromatic hydrocarbons exposure with cardiovascular disease and the mediating role of inflammatory indices in US adults. *Environmental health and preventive medicine*, *29*, 70-70.
10. Alhamdow, A., Lindh, C., Albin, M., Gustavsson, P., Tinnerberg, H., & Broberg, K. (2017). Early markers of cardiovascular disease are associated with occupational exposure to polycyclic aromatic hydrocarbons. *Scientific reports*, *7*(1), 9426.
11. Zhang, Q. Q., Xing, J. B., Wang, H. W., Liu, J. T., & Chen, X. (2023). Analysis on contamination characteristics, pollution source identification and ecological risk assessment of polycyclic aromatic hydrocarbons of groundwater in a large coking plant site of province. *Huan Jing ke Xue= Huanjing Kexue*, *44*(2), 807-815.