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# Effect of polycyclic aromatic hydrocarbons on liver function in Basra oil company workers

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## ABSTRACT

Polycyclic aromatic hydrocarbons (PAH) are considered one of the most widespread categories of environmental pollutants. This study was conducted to discover the effect of PAH from the oil fields pollution in Basra on liver function. The relationship between PAH in air compared to blood serum and its effect on liver function parameters were studied. 120 blood samples were collected from male workers aged between 25-40 years from 3 different regions. Group 1 was from the Rumella field, while group 2 was from the West Qurna field, and group 3 was from an uncontaminated area far from the oil fields in the city center (control). Higher levels of PAH were found in group 1 and group 2 in the blood serum as compared to control in both air and serum. In control, significantly higher levels of PAH were found in air as compared to serum levels. As for PAH levels in the air, a higher level was detected in group 1 compared to group 2, while a lower level was detected in control. As for liver function tests, the levels of alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, and bilirubin were the higher level in group 1 and 2 compared to control. In contrast, the levels of albumin and total protein were lower in the group 1 and 2 compared to the control. In conclusion, it is suggested that environmental pollutants such as PAH may cause liver diseases by reducing the function of liver in human.

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## INTRODUCTION

Polycyclic aromatic hydrocarbons (PAH) are environmental pollutants resulting from the combustion of all types of carbon-containing fuels such as coal, wood, diesel, and fats. Upon combustion, PAH disperse into the air, water, and soil, making these substances hazardous and challenging to reduce exposure, thereby causing various health issues [1]. Humans are exposed to PAH through multiple pathways including ingestion, inhalation, or dermal absorption. The source of PAH exposure and environmental conditions like humidity and temperature significantly influence their toxicity and concentration in the environment [2].

The primary sources of PAH dispersion in the environment are industrial processes and vehicle emissions, with climatic conditions characterized by high temperatures leading to elevated levels of PAH in the atmosphere. PAH particles can adhere to dust particles and once inhaled, can be metabolized by the body into reactive substances that bind to DNA, potentially causing genetic mutations and accumulating in the lungs [3]. Also, consuming grilled or smoked foods exposes individuals to PAH, representing another significant dietary pathway for exposure [3].

Once PAH enter into the body, they are transported to several organs, with the liver being the primary site due to its key role in metabolic detoxification. The liver removes toxins from toxic chemicals, with liver biomarkers serving as important indicators of organ efficiency and health. Enzymes like alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are released into the bloodstream when the liver is damaged and are necessary for protein metabolism. Alkaline phosphatase (ALP) is another important enzyme used to assess liver and bone health, often elevated in liver failure or bile duct obstruction [4].

Direct exposure to PAH can cause oxidative stress, leading to cell damage and death. Indirectly, PAH may cause liver poisoning by interfering with fat metabolism, which can lead to liver disorders such as steatosis (fatty liver disease) [5]. Whereas slight increases in liver enzyme levels are signs of minor dysfunction in liver functions due to long-term exposure to low levels of PAH [6].

Liver proteins such as albumin (Alb), total protein (TP), and bilirubin (Bil) play critical roles. It's also essential to evaluate levels of Alb and TP. Alb, the most abundantly produced protein by the liver, is a key marker of its synthetic activity. Decreased Alb levels may indicate severe liver disease or long-term exposure to liver-damaging substances, such as PAH. Similarly, variations in TP levels can signify changes in liver function or the onset of disease [7]. Changes in the liver over time due to variations in TP levels may indicate changes in liver functions or the onset of disease. Elevated Bil levels can lead to several liver diseases such as cirrhosis or hepatitis, often exacerbated by PAH pollution [8].

Due to the complexity of PAH and their metabolites, numerous variables can affect how they interact with liver functions. These variables include genetic makeup, existing medical conditions, and previous exposure to other pollutants [9]. Thus, the current study aimed to discover the effect of PAH on liver function from the oil fields pollution.

## MATERIALS AND METHODS

### Study subjects and design

A total of 120 male participants, aged 25 to 40 years, were recruited for this study. Participants were selected using a simple randomization method from three distinct locations such as Rumaila oil field (Group 1), West Qurna oil field (Group 2), and central Basra city (Group 3: people from far regions from the oil fields from the city center used as control). Each group had 40 participants. This approach was employed to minimize selection bias and ensured a representative sample from different regions. Blood samples were collected over a one-week period during morning hours to mitigate the effects of diurnal biological variations.

### Consent of ethics

In the present study, venous blood was taken from apparently healthy persons working in oil companies. Written consent was sought and secured from all members of the study before their samples were collected. The study proposal was reviewed and approved by the ethical and Scientific Committee of the College of Medicine, Al-Nahrain University (No. 20231008) adherent to the guidelines of ethical practice of both national and international standards with regards to the treatment of subjects involved in research. This approach facilitates responsible conduct of all research activities aimed at protecting the persons who contributed their information and samples to serve the scientific purpose.

## Inclusion and exclusion criteria

*Inclusion criteria*

Participants must have been working for at least 5 years. Apparently, health well (physically and mentally), and male participants only.

*Exclusion criteria*

Workers with a history of liver diseases, current smokers, individuals with chronic medical conditions, medication use, and Gilbert's diseases.

## Preparing blood samples

Approximately 5 mL of venous blood was drawn from each participant, who had fasted overnight, using blood collection tubes free of anticoagulants. The collected blood samples were allowed to clot at room temperature (approximately 22-25°C) for 20 minutes. Following clot formation, serum was separated by centrifugation at 2000xg for 10 minutes using a calibrated centrifuge (Beckman Coulter). The serum was then aliquoted and stored at -80°C until further analysis.

## Serum analysis

*Biochemical assays*

Serum levels of ALT, AST, Bil, Alb, TP, and ALP were measured using a Cobas analyzer (Roche Diagnostics GmbH, Germany). The device was calibrated before each analytical session to ensure measurement accuracy, and internal quality controls were utilized to validate the results.

*Analysis of PAH*

PAH was extracted from serum samples using a continuous evaporation extraction method with a specific organic solvent (Hexane). The concentrations of PAH were determined by gas chromatography (GC) with a flame ionization detector (FID) using a Shimadzu instrument (Shimadzu Corporation, Japan). Instrument settings, including oven temperature, flow rate, and analysis time, were adjusted according to the manufacturer's recommendations.

## Air pollution analysis

Ambient air concentrations of PAH were measured using a photoionization detector (PID) (RAE Systems, USA). Air samples were collected from predefined locations within industrial and urban areas using air intake pumps equipped with fine particulate filters. The PID was calibrated with reference gases before each measurement session, and the instrument settings were configured in accordance with the manufacturer's instructions.

### Statistical analysis

The mean and ± standard errors (SE) of the data are shown. The statistical software for the social sciences (SPSS version 25) was used to conduct the statistical analysis. To ascertain the statistical significance among the groups, an ANOVA was used. The thresholds of 0.001 and 0.05 were employed to ascertain statistically significant variations.

## RESULTS

### Comparison of PAH levels in blood serum and air samples among the study regions

The results showed that the high level of PAH in the air has significant evidence with their high level in blood serum, as they were measured in three different zones in the air with three groups of individuals within the same zone (Figure 1). The level of PAH in the Rumella field was the highest (54.82 ppm) in the air and the highest level in blood serum (12.175 ppm) for workers in the same field. The level of PAH in the air in the West Qurna field (46.265 ppm) was lower than the Rumella field, corresponding to a drop in its level in blood serum (10.6 ppm) for workers in the same field. In the city center (controls), the level of PAH is much lower than in the fields above (7.9 ppm) in the air. As expected, no level of PAH in blood serum was found, in people living in the city center. Figure 1 showed the difference of PAH levels between the two groups (Rumella and West Qurna) with highly significant ($p<0.05$).

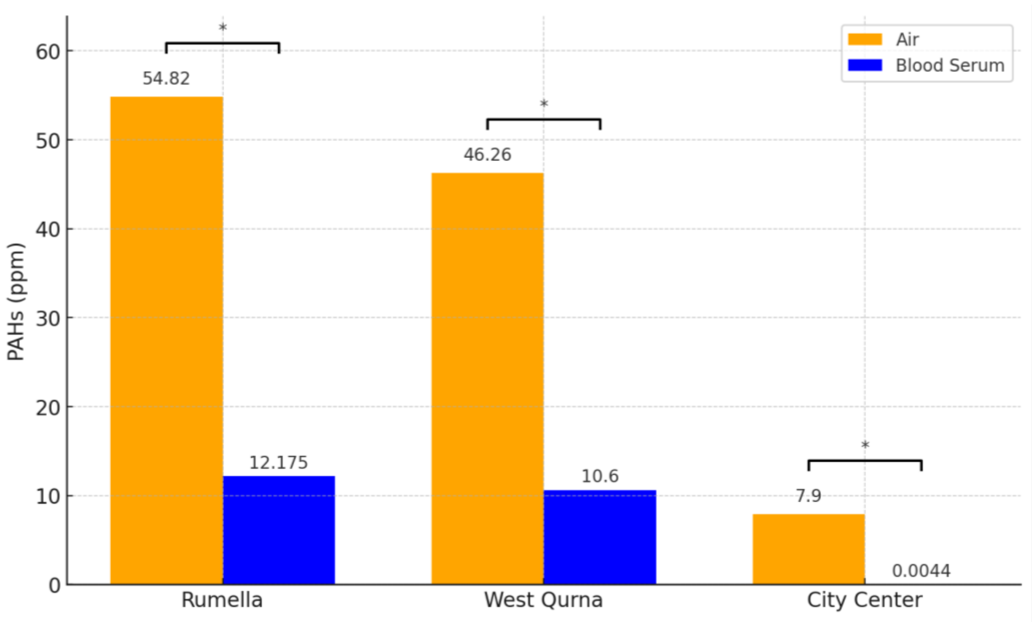


**Figure 1.** Comparison of PAH levels in blood serum and air samples among three different regions (City Center (Control), Rumella, and West Qurna groups). A statistically significant difference was also found when comparing the two groups (Rumella and West Qurna). Asterisk (*) means it reached statistical significance ($P < 0.05$).

### Effect on liver function parameters among the study regions

The liver function parameters such as ALT, AST, ALP, TP, Alb, and Bil levels are illustrated in Table 1. The data showed that the higher levels of ALT, AST, ALP, and Bil were found in West Qurna group (58.03±1.96 U/L, 47.95±1.55U/L, 112.20±4.55 U/L, and 1.41±0.06mg/dl, respectively) followed by the lower levels in the Rumella workers group (55.80±2.09U/L, 45.03±1.56U/L, 109.20±4.93U/L, and 1.31±0.07mg/dl, respectively) and the least level within the City Center group (36.30±1.51U/L, 29.03±1.61U/L, 76.18±3.45U/L, and 0.7378±0.04mg/dl, respectively). While TP and Alb showed higher levels in the City Center group (7.47±0.14g/dl and 4.29±0.10g/dl, respectively) then followed by lower level in the Rumella workers group (5.99±0.24g/dl and 3.22±0.14g/dl, respectively) and the least level within the West Qurna group (5.69±0.20g/dl and 3.18±0.15g/dl, respectively). A comparison between the Rumella and West Qurna groups showed a non-significant difference, while both of them were significantly lower as compared to the City Center group (Table 1).

**Table 1.** Comparison of liver function levels among study groups.

| Group | City Center | Rumella | West Qurna | P-Value |
|---|---|---|---|---|
| Test | Mean ± S.E. | Mean ± S.E. | Mean ± S.E. | |
| ALT (U/L) | 36.30±1.51 | 55.80±2.09 | 58.03±1.96 | 0.0001** |
| AST (U/L) | 29.03±1.61 | 45.03±1.56 | 47.95±1.55 | 0.0001** |
| ALP (U/L) | 76.18±3.42 | 109.20±4.93 | 112.20±4.55 | 0.0001** |
| TP (g/dl) | 7.47±0.14 | 5.99±0.24 | 5.69±0.20 | 0.0001** |
| Alb (g/dl) | 4.29±0.10 | 3.22±0.14 | 3.18±0.17 | 0.0001** |
| Bil (mg/dl) | 0.74±0.04 | 1.31±0.07 | 1.41±0.06 | 0.0001** |

ANOVA test was performed. Here, p-value <0.05 is significant (**). Albumin (Alb), total protein (TP), and bilirubin (Bil), alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP).

### Correlation analysis of PAH levels and liver function parameters among the groups

The relation between the PAH and liver function parameters Such as ALT, AST, ALP, TP, Alb, and Bil levels for the city center, Rumella, and West Qurna groups was determined as shown in Figures 2-7. There was a significant ($P<0.05$) with a positive correlation in ALT, AST, ALP and Bil levels between the Rumella and West Qurna groups (r = 0.59, 0.52, 0.58, and 0.57, respectively) as shown Figures 2-4 and 7. However, there was a very weak correlation in Alb and TP levels between the Rumella and West Qurna groups (r=0.4 and 0.33, respectively) as shown in Figures 5 and 6.

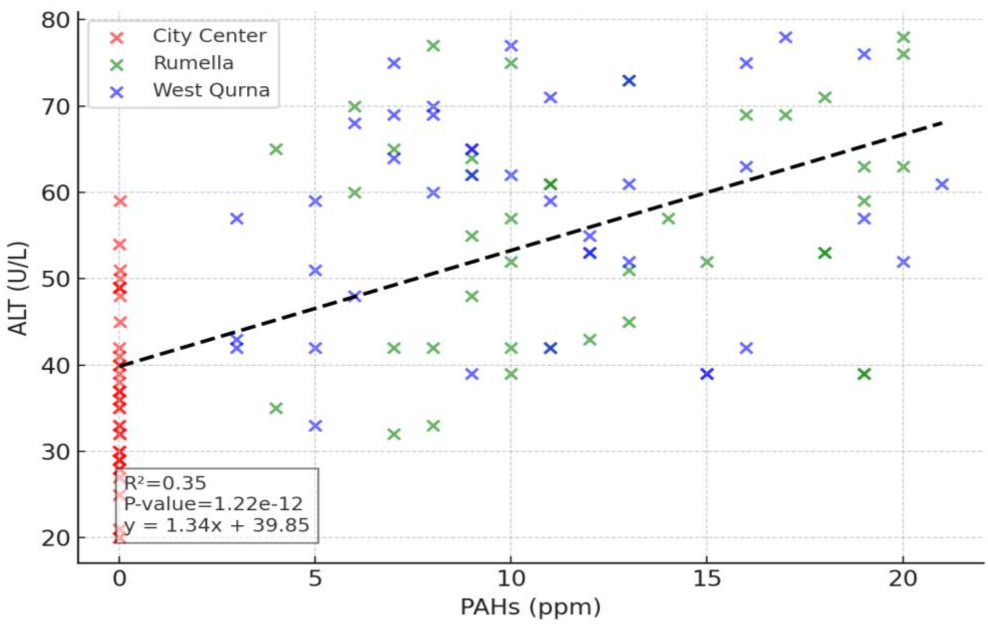


**Figure 2**. Correlation between PAH and ALT levels for the city center, Rumella, and West Qurna groups. There was a significant ($P< 0.001$) positive correlation between the Rumella, and West Qurna groups (r=0.59).

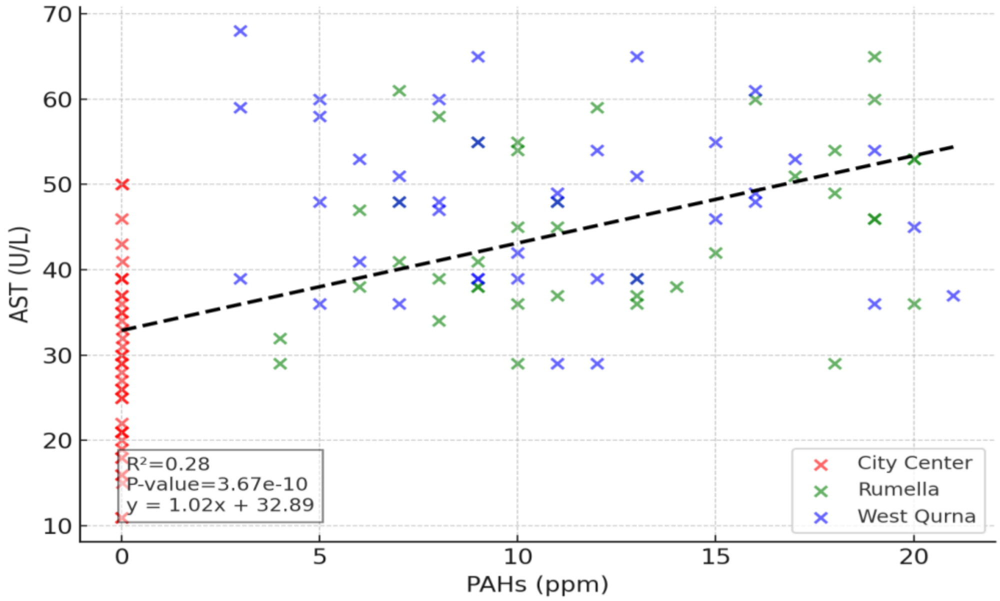


**Figure 3**. Correlation between PAH and AST levels for the city center, Rumella, and West Qurna groups. there was a significant (P< 0.001) positive correlation between the Rumella, and West Qurna groups (r=0.52).

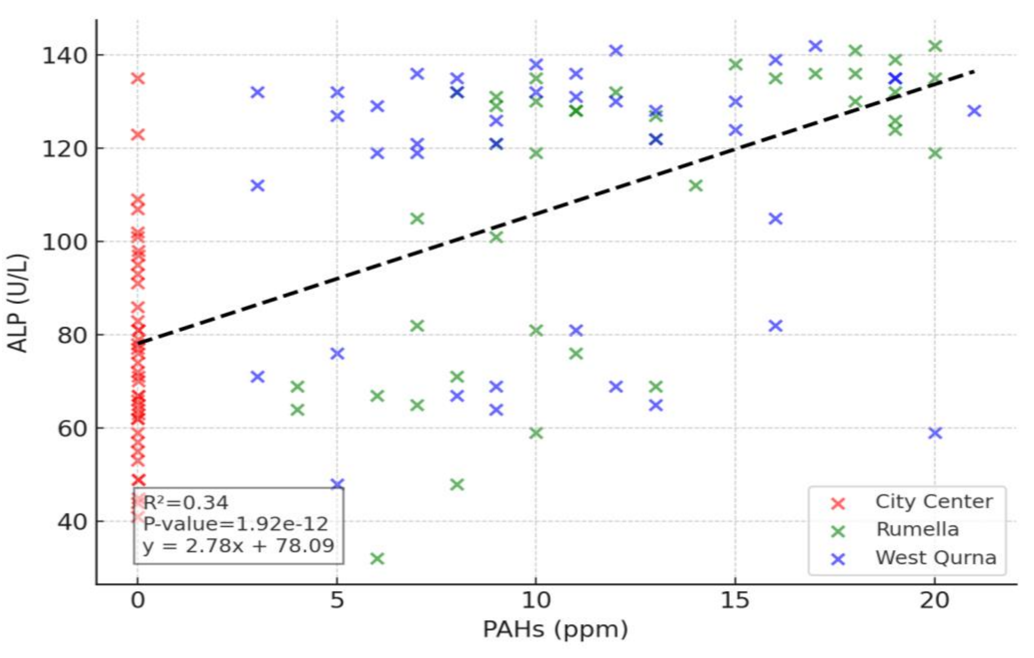


**Figure 4**. Correlation between PAH and ALP levels for the city center, Rumella, and West Qurna groups. There was a significant (P< 0.001) positive correlation between the Rumella, and West Qurna groups (r = 0.58).

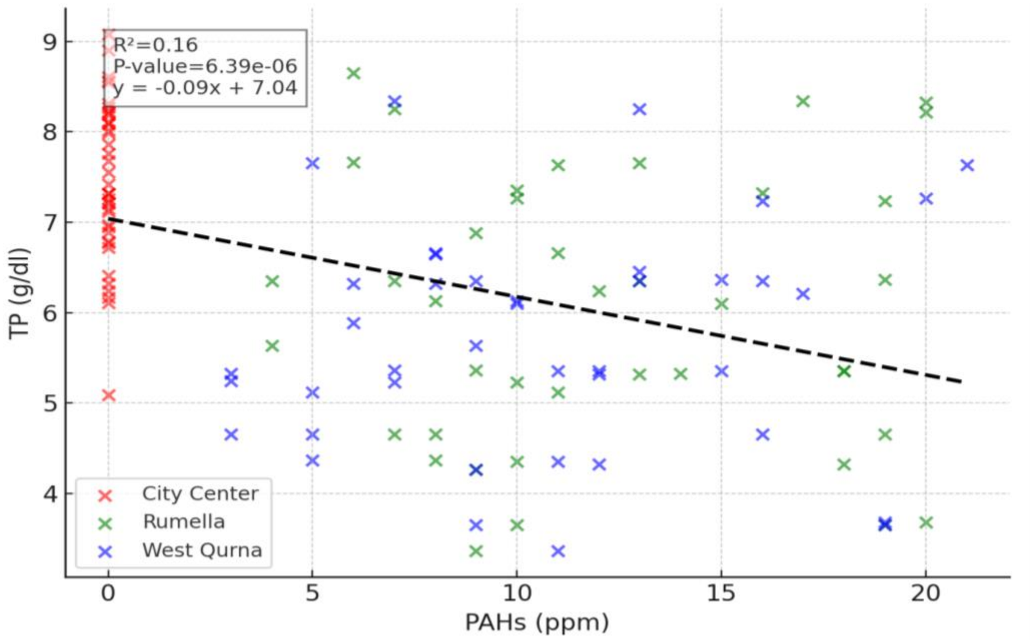


**Figure 5**. Correlation between PAH and TP levels for the City center, Rumella, and West Qurna groups. There was a weak correlation between the Rumella, and West Qurna groups (r =0.4).

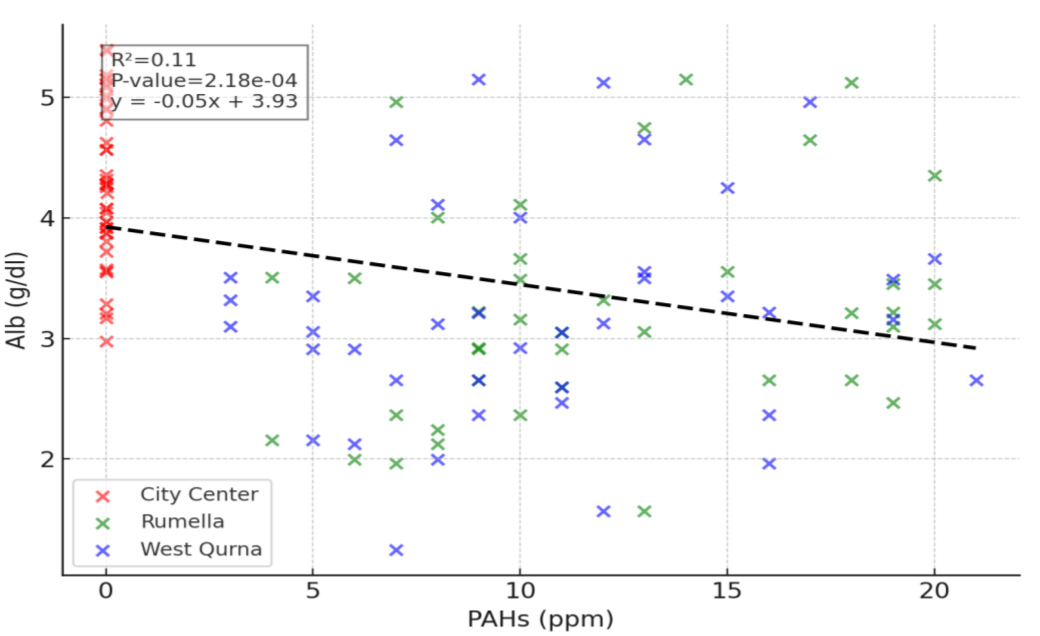


**Figure 6**. Correlation between PAH and Alb levels for the city center, Rumella, and West Qurna groups. There was a weak correlation between the Rumella, and West Qurna groups (r=0.33).

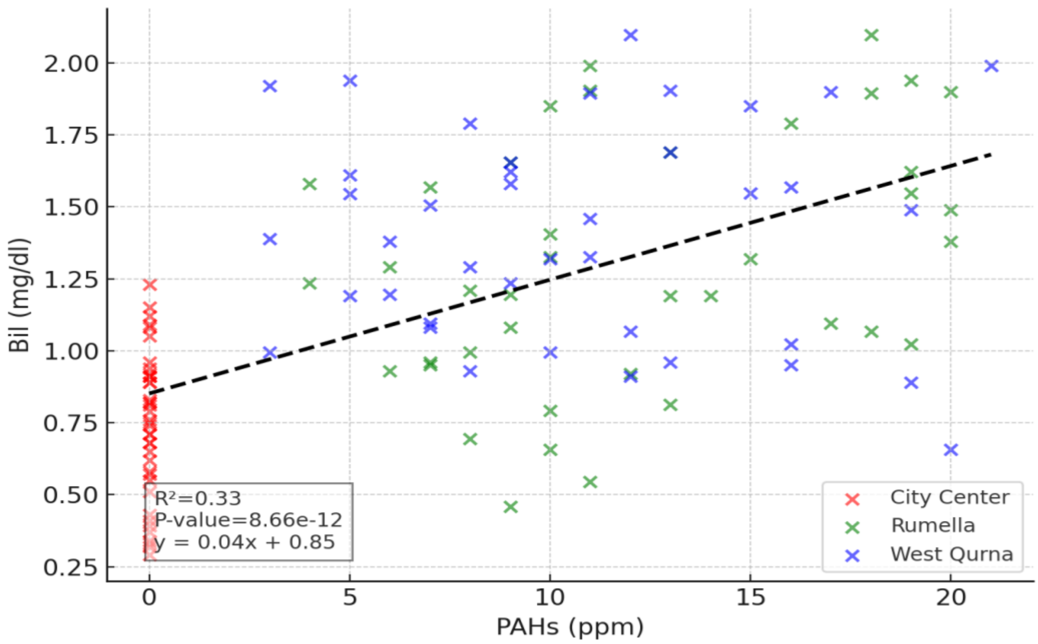


**Figure 7**. Correlation between PAH and Bil levels for the city center, Rumella, and West Qurna groups. There was a significant (P< 0.001) with positive correlation between the Rumella, and West Qurna groups (r=0.57).

## DISCUSSION

According to previous studies, pollution sources including PAH is generated from diesel combustion, oil extraction processes, and wood burning [10, 11]. This study is considered novel as no prior research has been found to measure PAH levels in the air and blood serum levels. Previous studies only used the period of exposure to PAH through years of work and direct exposure at the same time, showing a relationship between exposure duration and various diseases [12-14]. These findings support earlier research demonstrating the ability of airborne PAH to penetrate the respiratory system, enter the bloodstream, and ultimately contribute to systemic exposure and potential toxicity [15, 16].

In the present study, the levels of PAH were measured in the serum after taking samples from healthy individuals working in oil companies (Rumella and West Qurna fields) who had been exposed to PAH for over five years. At the same time, samples were also taken from people distant from the oil companies in the city center (control). PAH levels in the air were measured for the same areas over different periods and varying humidity and temperature conditions. The increase in PAH values in the serum was found to be related to their increase in the air, as shown in Figure 1, often linked to industrial activity. It is widely established that both direct inhalation and dermal absorption from the surrounding environment contribute to increased PAH levels in such settings. This highlights the significant importance of the study, as mentioned in previous research, which shows that the exposure period increases the incidence of various diseases and cancers due to the accumulation of PAH in the serum [17, 18].

The impact of PAH exposure on serum levels of liver functions (enzymes and proteins) was analyzed among the exposed groups, consisting of employees of oil companies in Basra (Rumella and West Qurna) who were directly exposed to PAH compared to the city center (control). These workers have been exposed to high levels of PAH, which significantly negatively affect human vital functions.

It is also important to note the differences in liver function tests among the different groups, as shown in Figures (2 to 7). Common indicators of liver damage or inflammation include elevated liver function parameters such as ALT, AST, ALP, and Bil with increasing levels of PAH. This supports other studies that found that high levels of ALT, AST, ALP, and Bil may indicate oxidative stress caused by PAH, which can then lead to liver damage. As evidence of a clear and direct correlation between high exposure to PAH and elevated liver enzyme levels, correlation coefficients (r values) for different compounds, such as 0.58 for ALP in Figure 4, show a medium to high positive [19 - 21].

Interestingly, when PAH levels increased, Alb and TP levels decreased. Since Alb and TP levels are often indicators of liver synthetic function, lower levels of Alb and TP indicate a reduction in liver functions. This weak correlation aligns with data derived from relevant toxicity research. It may imply that the liver's ability to produce these proteins may be compromised due to long-term exposure to high concentrations of PAH [22, 23]. The data show the stability of the links between changes in liver functions and PAH levels, as evidenced by a high degree of statistical significance ($P < 0.001$).

In summary, this study elucidates the relationship between environmental levels of PAH and human health, particularly liver functions, supporting the theory that high environmental exposure to PAH is strongly associated with adverse health outcomes [24].

There are some limitations of the study. The study's methodology uses a sizable sample size and thorough data analysis, which improves the validity of the results. However, the outcomes may be impacted by constraints, such as possible biases in the sample-gathering process or unconsidered environmental factors. Future studies that address these limitations may improve our knowledge of the effects of PAH. These limitations can be addressed by enhancing the randomness of sample collection to minimize potential bias. Expanding the study to incorporate additional environmental factors, along with replicating the study across different times and locations, will further improve the accuracy and reliability of the results.

The debate bolsters the need for continued investigation into the processes by which PAH affect liver function and other systemic consequences. Additionally, it emphasizes how crucial policy changes are in lowering exposure to and emissions of PAH, especially in urban and industrial regions. This should serve as a call to action for further research and focused public health initiatives to reduce PAH contamination.

## CONCLUSIONS

The results of this study indicate a substantial correlation between the levels of PAH in the air and the blood serum. Additionally, there is a link that suggests PAH have a significant impact on liver function biomarkers, as seen by the increase in the biomarkers for ALT, AST, ALP, and Bil and the decrease in the biomarkers for the Alb and TP. The high concentration of PAH in blood serum raises the possibility of liver damage in the future. A bigger population in subsequent multicenter research might introduce more confounding variables and produce different findings.

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## AUTHOR CONTRIBUTIONS

MAA designed the outlines and drafted the manuscript. MAA and HAA performed the experiments and analyzed the data. HAA and EAA reviewed the scientific information evident in the manuscript and the scientific contents described in it. All authors read and approved the final submitted version of the manuscript.

## CONFLICTS OF INTEREST

There is no conflict of interest among the authors.

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