International Information and Engineering Technology Association
Advancing the World of Information and Engineering

International Journal of Environmental Impacts
Vol. 8, No.1, February, 2025, pp. 167-172
Journal homepage: http://iieta.org/journals/ijei

Impact of Total Petroleum Hydrocarbons and Polycyclic Aromatic Hydrocarbons on the Liver Functions and Lipid Profiles of Oil Refinery Workers in Baghdad City

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https://doi.org/10.18280/ijei.080116

Received: 29 August 2024
Revised: 15 October 2024
Accepted: 24 October 2024
Available online: 28 February 2025

Keywords:
lipid profile (LP), liver function (LF), pollution, polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPHs)

ABSTRACT

In the past, studies that investigated pollution levels in developing countries showed that polycyclic aromatic hydrocarbon (PAHs) and total petroleum hydrocarbons (TPHs) compounds are commonly present in the environment. Oil refineries (ORs) were a significant source of pollution that impacted public health. In this study, the researchers have determined the PAH and TPH levels in the OR staff working at these organisations as they are constantly exposed to pollution. For this purpose, they determined the PAH and TPH levels in the serum samples collected from 70 OR workers (polluted group, PG) and 70 healthy individuals (control group, CG). They also assessed the impact of PAHs and TPHs on their lipid profile (LP) and liver function (LF). The results indicated that the blood PAH and TPH levels in the PG individuals were significantly higher ($P<0.05$) compared to CG. Furthermore, the PG individuals also displayed significantly higher ($P<0.05$) Total Cholesterol (TC), very LDL (VLDL), and triglyceride levels than the CG individuals. They also showed significantly ($P<0.05$) high Low-Density Lipoprotein (LDL) levels compared to CG. On the other hand, the PG individuals exhibited lower High-Density Lipoprotein (HDL) levels in comparison to the CG individuals. The workers included in the PG group also showed a significant ($P<0.05$) increase in their Alkaline Phosphatase (ALP) levels than those in CG. However, the Alanine Transaminase (ALT) and Aspartate Transaminase (AST) levels showed non-significant ($P>0.05$) variations in both groups. To conclude, it was noted that the PG individuals showed higher toxicity due to PAHs and TPHs since they were constantly exposed to higher pollutant concentrations compared to CG, which also affected their LP.

1. INTRODUCTION

Pollution can significantly reduce the quality of life of the people living in developing nations. Pollution is known as the submission to the environment of detrimental materials to humans and other living creatures. Contaminants are noxious liquids, gases, and solids created in upper-than-normal concentrations that minimize the features of the environment. The study of contamination is very important to saving the health of humans [1]. ORs are popular sources of contaminants like PAHs and TPHs. Scientific literature has presented a lot of evidence that shows the existence of PAHs and TPHs in the soil surface surrounding ORs. These compounds show negative environmental effects, such as air and water pollution, which are still being investigated and are a cause for concern. These reports may include sampling and analysing soil samples to determine the existence and concentrations of PAHs and TPHs. They have also studied the potential exposure pathways and evaluated harm to individual health and the environment [2].

According to the researchers, ORs pose significant harm to individual health when exposed to higher pollutant concentrations over an extended period. OR is an industrial operation manufactured where unrepeatable crude oil is processed into much-valued products. The oil industry also relies on petroleum conversion, where commodities are contaminated with PAHs, due to oil spills, tank leaks, and vehicle emissions [3]. The impact of PAHs on human health firstly depends on the period, exposure route, dose of concentration of PAHs, and the proportional poisoning of PAHs. PAHs are carcinogenic and endanger people and wildlife. They are a class of chemicals that are produced by the incomplete combustion of wood, oil, charcoal, garbage, gas, or another organic compound [4]. They are detected in various environmental matrices like sediment, soil, air, and water, and they also easily enter the body via ingestion, inhalation, or skin contact [5]. They are also detected in crude oil and its products, like diesel, gasoline, and heating oil, in addition to industrial processes such as oil refining [6].

PAH exposure is linked to health hazards, which include liver damage in fish, lower ALT also AST activities [7], and hepatic dysfunction [8]. The liver functions as the primary gland in the body and is considered the biggest gland, regulating various physiological processes. Thus, deadly liver disorder is perhaps the leading reason of death [9]. The liver is especially sensitive because of its detoxification and metabolic functions. The liver is especially exposed to its poisonous impacts. The liver showed increased sensitivity compared to other organs since its main organ has the essential role of being responsible for the digestion of drugs (xenobiotics). The liver especially works to reduce the toxicity of drugs. This organ pledges a multi-stage process in the metabolism of foreign substances [10]. PAH exposure can give rise to many complex and different mechanisms leading to impaired LF. Under another circumstance, natural communication with household products, like pesticides, constitutes one of the main sources of pollution, and with the secrecy around these substances, they may persist longer in the environment. These features permit pesticides to be within a chemical group of materials known as "Persistent Organic Pollutants" (POPs) due to their relatively slow rate of decomposition and high affinity for fats. It has a disturbing toxic appearance, and remains in tissues for long periods of time, particularly in fatty tissue. Furthermore, POPs have minimal volatility and as a result, can disperse over long distances and be widely distracted by ambient currents and air [11]. PAHs may be metabolically activated by liver cytochrome P450 enzymes, resulting in the generation of reactive metabolites that harm cellular components like DNA, proteins, and lipids [12]. In the past, studies have primarily concentrated on assessing the relationship between exposure to PAH and serum lipid levels in the public. Among the different health points, the potential association between exposure to PAHs and the levels of blood lipids is a nascent region of anxiety. Despite numerous previous studies that have monitored the association between the exposure of PAH and lipid profiles, there are still more studies that must be done (like a larger sample size, expansion of the studies of lipid measurements, etc.) [13].

PAH exposure is related to changes in serum LP, such as an elevate in TC, LDL, and triglyceride levels, also a decrease in the HDL level. Blood lipid disturbance has been known as a significant hazard agent for the evolution of disease, it is the leading reason for death around the world. In addition, individual agents like both the genes and the nature of life participate in the development of dyslipidemias [14]. There is insufficient data connecting PAHs to dyslipidemia, even though it is recognised as a major global health problem [15].

Many studies investigated the association between PAH and variations in serum lipid levels. For example, the author showed a link between urine higher OH-PAH and a greater risk of increased LDL and TC levels [16]. A different 6-year longitudinal epidemiological study found a link between increased hydroxyl-phenanthrene and LDL introduction. Despite previous researches have referred to PAHs as hazardous health agents, appear association between the exposed of PAH and blood lipid profile is missing yet, the remaining mechanism is also predominately unknown [17].

Studies about animals have offered additional support to these results, as PAH exposure altered the blood lipid levels by enhancing hepatic absorption and lipid production. These modifications have a variety of troubles, including hepatocellular membrane injury, hepatic inflammation, and disruption in the signal system, as demonstrated in the C57BL/6 mice model [18].

TPHs are a combination of several compounds found in petroleum or crude oil products. They may also be emitted at different phases of oil refining, processing, and transportation [19].

TPHs are a class of chemicals that might affect several organ systems. TPHs is an expression used to express oil contains hydrocarbons present in crude which may be measured in the environment. They are a mixture of various parts of oil hydrocarbons. Petroleum compounds consisting completely of hydrogen and carbon are known as hydrocarbons (HCs). They consist of a wide range of compounds with different molecular masses [20]. They can cause hepatotoxicity, potentially leading to liver malfunction. For instance, TPHs typically found in gasoline can cause severe intoxication at small doses that can induce hepatotoxicity and are associated with liver disease [21]. This study aims to evaluate the serum PAH and TPH levels in OR workers and examine their impact on LP and LF.

2. EXPERIMENT

2.1 Subject and samples

The study investigated 70 OR workers (polluted group, PG) and 70 perfectly healthy people (control group, CG). Individuals who could not fulfill the established criteria were excluded from this study, which included people submitting incomplete questionnaires, those not providing serum samples, those with a history of thyroid disease or any other endocrine disorder, smokers, or pregnant women. The researchers collected the fasting vein blood samples of everyone between December 2023 and March 2024. The blood samples in the gel tubes were centrifuged at 1500 × g for Ten minutes, also the sera were then stored in Eppendorf tubes at -20°C until further analysis.

2.2 Methods

The researchers measured the PAH and TPH levels in the collected serum samples using the gas chromatography technique (Shimadzu® GC-2010 Pro, Japan). They further determined the triglycerides, TC, VLDL, HDL, LDL, AST, ALT, and Alkaline Phosphatase (ALP) levels using the Roche Diagnostics® cobas® e 411 Analyzer (Germany).

2.3 Statistical analyses

The data were statistically analysed with SAS/STAT® 9.1. All results appeared as mean ± Standard deviation (STD). The significant differences noted in the mean values of the two groups were assessed with the independent t-test. The researchers further calculated the correlation coefficients (r) for all the determined parameters. The MedCalc statistical software was used for data analysis, it is especially beneficial for construction graphs and statistical tests. Values showing $P<0.05$ were considered statistically significant, P value means the probability of rejecting the null hypothesis when it is true. SAS/STAT® 9.1 could have been chosen due to its reliability, and the specific statistical techniques it introduces.

3. RESULTS

Table 1 displays the recent features of all participants listed in this study. The data indicated that the people in the CG showed a mean age of 45.28 ± 8.22, while those in PG were aged 49.68 ± 9.30. Also, the average BMI of the people in CG was 26.35 ± 2.87 Kg/m^2, while that in PG was 26.73 ± 3.32 Kg/m^2.

Table 2 presents the LF parameters determined in this study. The variations noted in the ALT levels were seen to be non-significant (P>0.05) in the case of PG individuals (18.19 ± 5.50U/L) compared to those estimated in CG (16.60 ± 4.77 U/L). Furthermore, the variations in AST were also seen to be non-significant (P>0.05) in PG individuals (23.14 ± 7.19 U/L) in comparison to the CG (21.96 ± 5.23 U/L). The PG individuals offered a significant (P<0.05) increase in their ALP concentrations (86.15 ± 24.60 U/L) compared to the CG (73.97 ± 18.80 U/L). The individuals in the 2 groups showed no significant variations (P>0.05) in their ALT and AST levels (Table 2). Table 2 also presents the values of the LP parameters. As noted in the table, the TC concentration in the PG individuals (188.15 ± 42.17 mg/dL) was significantly increased (P<0.05) compared to CG individuals (170.57 ± 23.69 mg/dL). The data indicated that the triglyceride concentration in PG individuals (186.22 ± 57.11 mg/dL) was significantly higher compared to the CG participants (113.51 ± 44.34 mg/dL). On the other hand, the individuals in PG offered a significant decrease (P<0.05) in their HDL concentrations (39.22 ± 9.13 mg/dL) than that noted in CG individuals (44.08 ± 8.22 mg/dL). Furthermore, the participants in the PG group offered a significant increase (P<0.05) in their LDL (107.60 ± 35.55 mg/dL) and VLDL concentrations (35.10 ± 13.23 mg/dL) compared to the LDL (83.06 ± 18.43 mg/dL) and VLDL levels (29.28 ± 6.89 mg/dL) in the CG individuals.

Table 1. Presents features of the study subjects

Parameter	Polluted Group	Control Group
Age (year)	49.68 ± 9.30	45.28 ± 8.22
BMI (Kg/m^2)	26.73 ± 3.32	26.35 ± 2.87

Table 2. Clinical parameter's outcomes

Parameter	Polluted Group	Control Group	P-Value
ALT (U/L)	18.19 ± 5.50	16.60 ± 4.77	0.12
AST (U/L)	23.14 ± 7.19	21.96 ± 5.23	0.35
ALP (U/L)	86.15 ± 24.60	73.97 ± 18.80	0.006
Cholesterol (mg/dL)	188.15 ± 42.17	170.57 ± 23.69	0.01
Triglyceride (mg/dL)	186.22 ± 57.11	113.51 ± 44.34	<0.0001
HDL (mg/dL)	39.22 ± 9.13	44.08 ± 8.22	0.006
LDL (mg/dL)	107.60 ± 35.55	83.06 ± 18.43	<0.0001
VLDL (mg/dL)	35.10 ± 13.23	29.28 ± 6.89	0.007

Table 3. Clinical parameter's outcomes

Parameter	Polluted Group (Workers Exposed for 10-24 Years)	Control Group	P-Value
		(Workers not Exposed)	
PAH (ppb)	3.24 ± 1.00	0.12 ± 0.03	<0.0001
TPH (ppb)	2.17 ± 0.59	0.14 ± 0.07	<0.0001

Table 3 presents the PAH and TPH levels determined for the 2 groups. The PAH levels in the PG individuals (3.24 ± 1.00 ppb) were seen to be significantly elevated (P<0.05) compared to those noted in CG (0.12 ± 0.03 ppb). Furthermore, the TPH level in the PG individuals (2.17 ± 0.59 ppb) was seen to be significantly increased (P<0.05) compared to the people in CG (0.14 ± 0.07 ppb).

A correlation analysis with Pearson's r was utilised to determine the relationship between PAHs, TPHs, and other parameters in the blood samples collected in the study. Table 4 indicates that there was no significant connection between CG levels and the studied parameters. There was a positive correlation found between TPHs also cholesterol, triglycerides, LDL, VLDL, and HDL. Table 5 shows a significant but weak relationship between serum PAHs and AST activity (r = 0.317*, P = 0.025). There was a negative correlation found between PAHs cholesterol, triglycerides, LDL, VLDL, and HDL.

Table 4. Correlation between PAH, TPH and other variables in control group

Control Variables	PAH		TPH	
	r	p	r	p
ALT	0.066	0.650	-0.072	0.621
AST	0.072	0.621	-0.156	0.279
ALP	-0.030	0.834	0.054	0.708
Cholesterol	-0131	0.366	0.157	0.277
Triglyceride	0.020	0.888	0.183	0.203
HDL	-0.206	0.151	0.128	0.376
LDL	-0.120	0.064	0.136	0.347
VLDL	0.172	0.232	0.072	0.621
PAH	-	-	-0.273	0.055
TPH	-0.273	0.055	-	-

Table 5. Correlation between PAH, TPH and other variables in polluted group

Polluted Variables	PAH		TPH	
	r	p	r	p
ALT	0.032	0.825	-0.094	0.516
AST	0.317*	0.025	-0.090	0.532
ALP	-0.158	0.274	-0.059	0.682
Cholesterol	-0.100	0.489	0.068	0.639
Triglyceride	-0.022	0.878	-0.024	0.871
HDL	-0.071	0.623	-0.167	0.248
LDL	-0.112	0.439	-0.055	0.707
VLDL	-0.169	0.242	0.015	0.917
PAH	-	-	0.153	0.290
TPH	0.153	0.290	-	-

*: significant

4. DISCUSSION

PAHs occur naturally in crude oil. In this study, the TPH and PAH concentrations in PG individuals were seen to be 3.24 ± 1.00 and 2.17 ± 0.59 ppb, respectively. The researchers noted the existence of different PAHs in the serum of the PG participants such as acenaphthylene, benzo [ghi] perylene, benz [a] anthracene, chrysene, benzo [a] pyrene, dibenzo [a,h] anthracene, naphthalene, indeno [1,2,3-cd] pyrene, fluoranthene, and pyrene.

In a few earlier studies, the researchers compared the toxicity of acenaphthylene and acenaphthene with naphthalene. According to their results, these compounds showed LD50 values ranging between 0.6-1.7 g/kg [22].

Monago et al. [23] described the uncontrolled PAHs emissions that can affect human health. Different PAHs in the blood samples that harmed human health included naphthalene, pyrene, fluoranthene, phenanthrene, and chrysene. Furthermore, PAH emission was seen to be inversely proportional to carbon dioxide. According to Braatveit et al. [24], when twelve crude oil operation executors were exposed to ethylbenzene, C_6H_6, and xylene over 3 successive 12 h work shifts, they displayed no significant effect on the hydrocarbon levels in their blood samples.

The body is affected differently by the chemicals found in various TPH fractions. Some TPH compounds, like toluene, C6H6, and xylene, impact the central nervous system of humans, in addition to blood, the immunological system, growth fetus, kidneys, liver, and lungs. A higher exposure can even lead to death. Toluene exposure at concentrations higher than a hundred parts per million for some hours can result in sleepiness, queasiness, fatigue, and headache [21]. In this study, the researchers identified the presence of hydrocarbons such as dodecane, hexadecane, nonane, octadecane, tetracontane, and tetratetracontane with a total TPH concentration of 2.17 ± 0.59 ppb.

Studies published in the past have shown that ORs negatively impact human health; hence, these refineries are situated away from cities. In general, refineries are a significant fraction of the oil industry. Oil refineries are considered the main source of environmental contamination. Most refining wastes are considered hazardous, although to varying degrees, as expressed in toxicology tests. Moreover, several researchers have shown that liquid waste can often have less intense impacts on reproduction and growth than its lethal impacts [25]. However, some ORs are located closer to the consumers in the cities. An earlier study noted that residents living near OR in Jordan experienced negative health effects, such as respiratory difficulties, skin ailments, and a perception of bad health [26].

Like many other cities in underdeveloped nations, Baghdad is home to many ORs. However, the influence of these key facilities on human health is not apparent. Furthermore, none of the researchers in the past have evaluated the presence of Volatile Organic Compounds (VOCs) in humans who are constantly exposed to the environment at the ORs. As a result, the researchers in this study investigated the influence of OR on human health by determining the PAHs and TPH levels in addition to assessing the LP and LF in people who were continuously exposed to the test environment.

In this study, the researchers detected significantly elevated TC, triglyceride, and LDL levels, also significantly reduced HDL levels in the blood samples collected from PG individuals (Table 2). Analogous results were mentioned by Yu et al. [27].

The association between ambient PAH exposure and insulin resistance, cigarette smoking, and also a higher commonness of metabolic symptoms was highlighted by studies that assessed the data [28]. Similarly, an earlier study that was performed in South China discovered a favourable relationship between higher urine PAH metabolite levels and alterations in blood TC and LDL levels. Modern empirical studies have proposed that severe exposure to PAH stimulation of hyperlipidemia can also noticeably reduce the metabolism of lipids in mice [29].

However, the fundamental processes underlying the complicated link between OH-PAH exposure and dyslipidemia are unknown. The authors have shown that PAHs can stimulate the Aryl hydrocarbon Receptor (AhR) signaling route after linking to AhR [30]. The stimulated AhR signaling route may increase the appearance of specific epoxy-genases, leading to an increase in dyslipidemia [31]. Additionally, it was postulated that the stimulated AhR route may impact TG by inhibiting hormone-induced adipogenesis [32], offering an alternate mechanism that disrupts lipid metabolism.

Furthermore, in vivo and in vitro studies have demonstrated that PAHs can stimulate the AhR signaling route, which metabolises PAHs by cytochrome P-450s, resulting in the formation of reactive oxygen species (ROS) [33]. Metabolize PAHs by bio-oxidation of the ring by P-450 to active substances and then produce harmful (ROS), they can reach the fatty molecule and attack it, as well as cause changes in fat metabolism and internal balance. The ROS reason oxidative deterioration also interfering with lipids, and generating to dyslipidemia [34]. However, this theory cannot properly explain the unexpected results.

Various processes may lead to the deregulation of these VOCs. The PAHs and TPHs are VOCs that are especially harmful because of their toxicity and potential health consequences [35]. They are popular carcinogens and are related to a variety of health problems, like dyslipidemia [36], and liver malfunction [37].

In this study, all ALT and AST ranged among the normal rate (Table 2), while ALP was significantly increased in PG individuals than CG. The researchers concluded that PAH and TPH exposure increased blood TC, triglyceride, and LDL levels while decreasing HDL levels. This indicated that an increase in PAHs and TPHs affected the LP of the participants included in the study.

Previous research indicates that serum levels of AST, bilirubin, ALT, creatinine, and urea were significantly elevated in individuals exposed to petroleum derivatives compared to unexposed humans. However, the workers at the fuel station had higher AST and ALT compared to those appearing by the people of control health, there is a relationship between the period and the enzyme level also working age [38]. Contrary to what is widely believed, levels of liver enzymes, like AST and also ALT, are not affected by exposure to a level of organic solvents. Some authors also referred to exposure to organic solvents that did not impact liver enzymes, including ALT and AST [39]. Moreover, expected abnormalities of the liver (like high ALS, ALT, as well as ALP) differ with dose, also management technology (like, inhalation vs. dermal absorption) [40]. The emissions of refinery cause damage to the biological pathways and organs, such as blood, thyroid, lipid and liver disorders. Consequently, processes are required to prevent contamination from using refineries.

5. CONCLUSIONS

In this study, the researchers utilized a new comparative analysis technique for specifying the complex connection between TPH and PAH, liver dysfunction, and dyslipidemias in ORs staff. The findings exposed a significant elevate in TPH also PAH levels in ORs workers, increasing major fears related to possible health risks not only for ORs staff but also for people living near these facilities. These results show that PAH also TPH exposure are attached to the development of dyslipidemias between OR workers. After analysing the results, the researchers concluded that the detrimental effects of OR were associated with negative health consequences like LP and LF characteristics. However, the presented study has shown several limitations, such as sample size. Moreover, by providing a larger sample size, the results are only for workers of the refinery in Baghdad and may not be applicable in different regions. Another limitation in this study is Confounding Variables. This research may not have adequately controlled for other confounding factors that could influence liver function and lipid profiles, such as dietary habits, lifestyle choices, or other environmental exposures with could affect the interpretation of the causal relationships being investigated. This type of research is significant for developing targeted enlightened policies to protect the health and well-being of the ORs workers also communities affected by environmental contaminants.

ACKNOWLEDGMENT

The researchers would be grateful to thank the Ministry of Science and Technology in Iraq for attribution in this study.

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