Libyan Med J. 2025;17(3):374-383
https://doi.org/10.69667/lmj.2517311
Libyan Medical Journal
https://lmj.ly/index.php/ojs/index *eISSN: 2079-1224*

Original article

Using GC –Mass Method for Determination the Hydrocarbon Compounds in Some Vegetable Samples at Derna City, Libya

Zaenab Habil[1], Najat Ben Arous[2], Nuri Masoud[3], Hamad Hasan[4]*

[1]Chemistry Department, Faculty of Science (Derna), Derna University, Libya
[2]Chemistry Department, Faculty of Education, El-Mergib, Libya
[3]Chemistry Department, Faculty of Science (Al-Quba), Derna University, Libya
[4]Chemistry Department, Faculty of Science, Omar Al-Mukhtar University, Libya
***Correspondence email**. hamad.dr@omu.edu.ly*

***Keywords**:*
Extraction, Hydrocarbon, Vegetables, Aromatic.

ABSTRACT

The purpose of this study was to identify and quantify the polycyclic aromatic hydrocarbons (PAHs) in a variety of vegetables from various places in Derna City, Libya. The GC-MS equipment was used to identify and determine the types of aromatic hydrocarbon molecules. The findings demonstrated that polycyclic aromatic hydrocarbons were present in every vegetable sample that was analyzed. The findings indicated that the vegetables' total amounts of polycyclic aromatic hydrocarbons varied as follows: 8.257 µg/g for tomato, 8.258 µg/g for pepper, 7.841 µg/g for eggplant, and 8.216 µg/g for zucchini. The origin and sources of the investigated polycyclic aromatic hydrocarbons in vegetable samples were estimated using a few computed ratios, as the ratio (LMW/HMW) of low molecular weight (LMW) to high molecular weight (HMW) chemical composition. Diagnostic ratios of the concentrations of specific pairs of aromatic hydrocarbons, such as (∑COMB/∑PAHs), Phe/Ant, Flu/Pyr, Inp/(Inp + Bghip), Bap/(Bap + Chr), and Ant/(Ant + Phe), were also employed to investigate the origin of the polycyclic aromatic hydrocarbons. The findings showed that petrogenic and pyrolytic sources were the primary sources of PAHs in vegetables. The investigation came to the conclusion that the majority of the PAHs in the study samples came from either pyrolytic or direct petroleum sources.

Introduction

Because of its fertile soil, temperate climate, and labor, Derna is an agriculturally oriented region that is heavily dependent on growing vegetables. This is especially true in some areas, like Wadi Derna and El-fatiah, where over half of households reported being involved in agricultural activities [1]. The size of this plant is 31,511 square kilometers, and it grows in two seasons: winter and summer. It is situated in the northeastern region of Libya, where the average domestic production of vegetables is estimated to be 1550,000 tons, while Libyan agricultural fields make up less than 3% of the country's total territory. Derna's primary crops are vegetables such as tomatoes, cucumbers, peppers, beans, peas, onions, lettuce, cilantro, and parsley [2]. Naturally, vegetables are considered the most vital component for human health and protection; they are essential for balanced meals because they contain dietary fiber, antioxidants, minerals (such as Fe, K, Mg, Zn, Ca, etc.), nitric oxide, and dietary fiber. Consuming vegetables on a daily basis has been closely associated with better gastrointestinal health, clear vision, and a lower risk of heart disease, stroke, and chronic conditions like diabetes, obesity, and some types of cancer. Furthermore, vegetables make up a sizable amount of the global human diet and are essential for human nutrition, especially as sources of phytonutriceuticals, which include vitamins A, B1, B6, B9, C, and E, as well as carbohydrates, protein, and phytochemicals like flavonoids, phenolic compounds, carotenoids, and bioactive peptides. Vegetables come in a variety of species and might be edible seeds, fruits, roots, or leaves. Every species has a unique contribution to the food [4]. However, the environment, which is heavily contaminated, has an impact on the veggies. The concentration of hazardous gases and compounds has increased to unsafe levels due to urbanization, industry, and vehicle pollution, harming people, animals, and plants [5]. Among the most significant and hazardous pollutants found in soil are polycyclic aromatic hydrocarbons (PAHs), which can spread to crops and damage the ecosystem. PAHs are found in soil, water, and the atmosphere [6]. The type of PAH compounds, their physicochemical characteristics, and the physiological state of the plant all have a direct impact on how well they are absorbed by vegetables, which can do so by foliar or root uptake. While high molecular mass PAHs can contaminate the surface by air fallout, low molecular mass PAHs can be absorbed by surface adsorption in plants. A potential route from polluted soil to plant roots was identified by the direct correlation between soil and plant PAH contents [7]. Both direct contact with soil or ingestion of it, as well as indirect exposure through the eating of crops and grazing animal products, can expose

***Received**: 11-06-2025 - **Accepted**: 06-08-2025 - **Published**: 16-08-2025*

humans to soil pollution. There are three ways that the latter could occur: (1) ingestion (deliberate or unintentional, geophagy); (2) inhalation; and (3) penetration or absorption through the skin. One potentially significant route of exposure to environmental contaminants may be through the ingestion of dust and soil particles. Hand-to-mouth contact, which is very common in youngsters, airborne dust, and improperly cleaned fruits and vegetables can all result in accidental consumption. Moreover, the main cause of animal product contamination (meat, milk, or eggs) may be farm animals kept outdoors, accidentally consuming soil containing POP. According to recent studies, soil poses a serious risk matrix for POPs entering the food chain, especially in regions with high contamination levels [8]. This study aims to determine the types and contents of polyhydrocarbon compounds in different vegetables collected from Derna city, Libya.

Methods

Vegetable Samples

Between March and June 2023, the vegetable samples were gathered at random from a number of farms. About 2 kg of samples of each of the four vegetable species were collected; the examined samples are displayed in (Table 1). Samples of vegetables were brought to the lab in plastic bags for protection. After being cleaned with tap water and deionized water, fresh samples were allowed to air dry before being meticulously weighed. The samples were cut into little pieces and then dried. Then dried once more in an oven set at 75 °C for 36 hours. To obtain a representative sample, it was then ground into powder using a food processor (blender) and sieved through a 2 mm nylon sieve. and the sample was moved into specimen cans in the proper volume.

Table 1. The studied Vegetable samples

s. no.	**Vegetables**	**Species**	**Sites**
1	Tomato	Fruiting	El–Fatiyah 1
2	Zucchini	Fruiting	Sidi khalid 2
3	Pepper	Fruiting	El–Fatiyah 2
4	Eggplant	Fruiting	Ain mara

Polycyclic Aromatic Hydrocarbons Analysis

Analysis of PAHs was conducted using the methods provided by some authors [9 -12].GC/MS was used to examine the polycyclic aromatic hydrocarbons (PAHs) components. Each chemical in the vegetable extract was identified by comparing its chromatogram and retention durations with those from HP memory and the EPA standard at the Marine Science Institute's central lab (Alexandria, Egypt). Different procedures, such as extraction, cleaning, and fractionation, instrumental analysis, and analytical quality control, were used to examine the samples for PAHs. Excel was used to tabulate and statistically analyze the collected data.

Extraction Step of PAHs for Vegetables Sample

30 g of anhydrous sodium sulfate was added to 0.5 g of agricultural soil and 1 g of the wet weight of each vegetable species. The mixture was then mixed for five minutes at high speed. After that, the mixture was extracted for eight hours using a Soxhlet and 200 milliliters of methanol. To saponify the lipids, 20 milliliters of 0.7 M KOH and 30 milliliters of distilled water were added to the flask, and the reflux was maintained for two hours. Using 80 milliliters of hexane, the contents of the extraction flask were extracted three times in a separating funnel. Anhydrous sodium sulfate was used to dry the three extracts before they were filtered through glass wool. Prior to cleaning and fractionation, the hexane fraction was concentrated using a rotary evaporator down to approximately 15 ml at 300 °C. It was subsequently concentrated to a volume of 1 ml using a nitrogen gas stream [9-12].

Instrumentation and Analysis Conditions

There are two components to the GC-MS instrument: The mass spectrometer (MS) detects and measures the chemicals in the sample after the gas chromatograph (GC) separates them. The sample is injected into the GC inlet after being sufficiently cleaned. There, it is vaporized and transported by an inert gas (mobile phase), usually helium, through a column that has a particular polymer coating on the inner surface (stationary phase). In addition to adsorption to the stationary phase, the molecules separate according to their volatility, with smaller molecules moving more quickly than larger ones. Retention time is the amount of time that passes after the molecule leaves the column. Since the molecules must be charged in order to pass through the filter (mass analyzer) in the mass spectrometer, it is important that the molecules are ionized at the end of the column. The filter separates the ions according to properties related to the mass-to-charge ratio (m/z), which varies depending on the analyzer. Throughout the investigation, the mass-to-

***Received**: 11-06-2025 - **Accepted**: 06-08-2025 - **Published**: 16-08-2025*

charge ratio (m/z) is computed. The filter separates the ions according to properties related to the mass-to-charge ratio (m/z), which varies depending on the analyzer. Throughout the investigation, the mass-to-charge ratio (m/z) is computed. The most popular mass filter is the quadrupole mass filter, which was used in this study. However, other filters, including sector field (SF) and time of flight (ToF), are also employed. Following their separation, the ions are sent through a detector that determines how many ions of a particular mass there are. A computer receives this data, records it all, and shows the mass spectrum [13].

Calculated ratios

R1, R2, R3, R4, R5, and R6 are some of the ratios that are used to identify the sources of aromatic compounds. These include the following:
R1 = Inp/ (Inp + Bghip)
R2 = Flu / (Flu + Pyr)
R3 = Bap / (Bap + Chr)
R4 = Phe / (Phe + Ant)
R5 = BbF / BKF
R6 = Ant / (Ant + Phe)
An indication of the origin of the aromatic hydrocarbons found in the samples can be obtained by computing these ratios. The kind and source of the hydrocarbon compounds are estimated using the values of these ratios as follows:
If R1 is less than 0.4, it indicates petroleum contamination; if R1 is greater than 0.5, it indicates hydrocarbon pollution from burning grass and wood [14]. Petroleum-derived hydrocarbon particles are present if the R2 ratio is within the range of 0.4; coal and combusted fuel are indicated if the R2 ratio is more than 0.4. Although the aromatic components are products of petroleum combustion, if the R3 is less than 0.2, uncombusted petroleum pollution is indicated; if the R3 is between 0.4 and 0.6. Additionally, if the R4 < 0.1 ratio is a sign of aromatic chemicals that come from a petroleum chemical source. On the other hand, R5 > 0.1 indicates that fuel has burned. Additionally, diesel, core oil, and coal are present if R6 > 0.1.

Ratio of Low Molecular Weight / High Molecular Weight of hydrocarbons

LMW = Fluorene + Phenanthrene + Anthracene + Naphthalene + Acenaphthylene + Acenaphthene
HMW = Bbf+ BKf + BaP + DBA + B (ghi) perylene + indenol pyrene + fluorananthene + pyrene + BaA+ chrysene

Results

The Polycyclic Aromatic Hydrocarbons (PAHs): contents of the vegetable samples under investigation were given in (Table 2). Furthermore, (Figures 1– 4) show the chromatograms of the compounds.

Table 2. GC/MS measurements of the polyaromatic hydrocarbon concentrations (µg/g) in the fruiting vegetable samples

PAHs Compound	**Vegetable Samples**				**Average**
	Tomato	**Pepper**	**Eggplant**	**Zucchini**	
	EL-fatiah 1	EL-fatiah 2	Ain mara	Sidi Khalid 1	
Acenaphthylene	0.327	0.327	0.326	0.326	0.327
Anthracene	0.429	0.430	0.424	0.426	0.427
Phenanthrene	0.556	0.557	0.531	0.538	0.545
Fluorene	0.315	0.318	0.309	0.313	0.313
Pyrene	0.115	0.113	0.112	0.113	0.114
Chrysene	0.508	0.499	0.498	0.498	0.500
Benzo(a) anthracene	0.716	0.725	0.716	0.716	0.718
Benzo(a) Pyrene	0.702	0.699	0.699	0.702	0.702
Benzo(b) fluoranthene	0.364	0.364	0.364	0.364	0.364
Benzo(k) fluoranthene	0.357	0.357	0.357	0.357	0.357
Indeno(1,2,3cd) pyrene	3.663	3.664	3.664	3.664	3.664
Dibenzo(a,b) anthracene	0.205	0.205	0.205	0.205	0.205
Benzo(g,h,i) perylene	N/A	N/A	N/A	N/A	0
	8.257	8.258	7.841	8.216	8.236

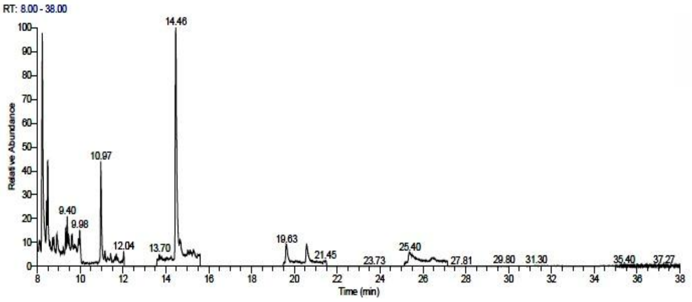

Figure1. GC-MS chromatogram of PAH compounds fraction of tomato sample at EL-fatiah-1 location

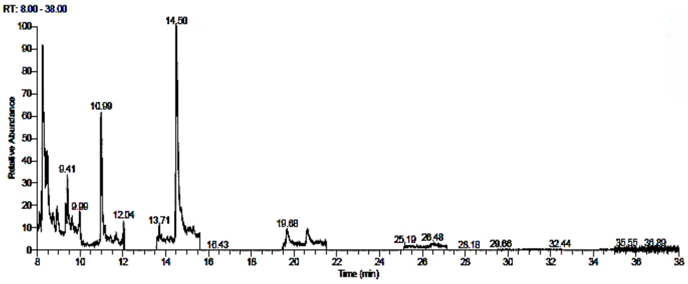

Figure 2. GC-MS chromatogram of PAH compounds fraction of pepper sample at EL-fatiah-2 location

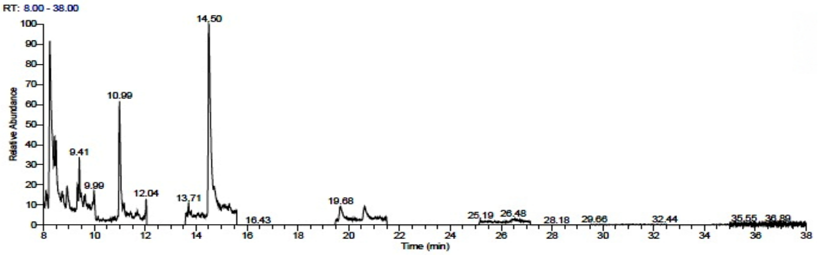

Figure 3. GC-MS chromatogram of PAH compounds fraction of eggplant sample at Ain Mara location

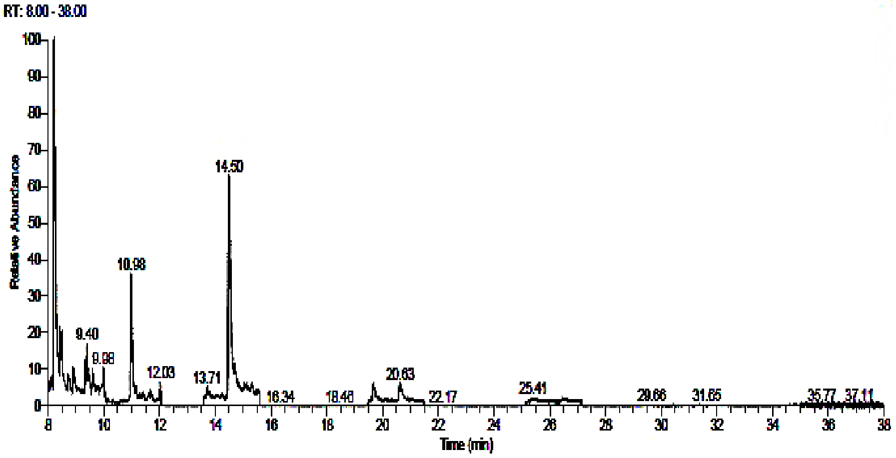

Figure 4. GC-MS chromatogram of PAH compounds fraction of zucchini sample at Sidi Khalid-1 location

Additionally, (Figure 5) showed the PAH values in the fruiting vegetable samples.

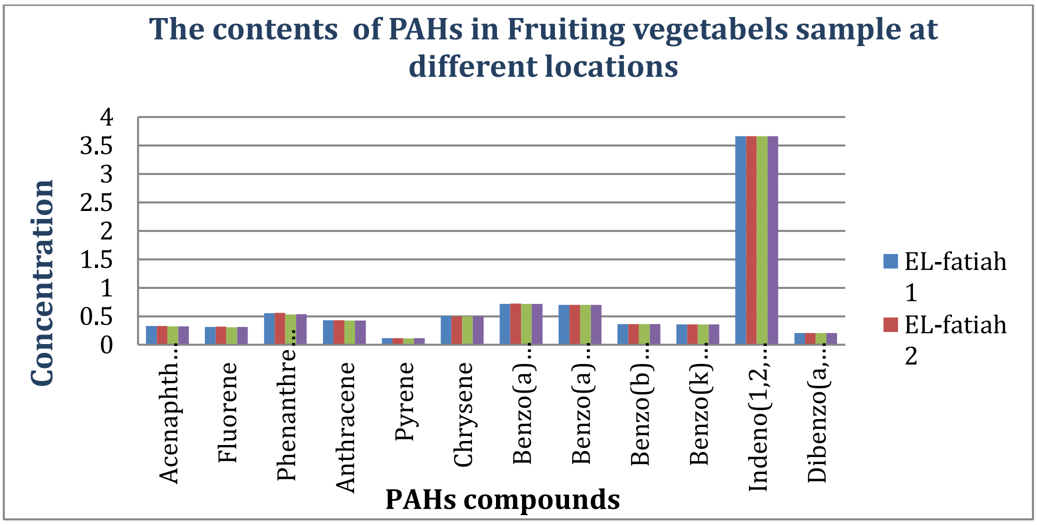

Figure 5. Distribution of the concentrations (µg/g) of poly aromatic hydrocarbons of fruiting vegetable samples at (EL-fatiah-1, EL-fatiah-2, Ain Mara, and Sidi Khalid 1) locations

Discussion

The main ways that PAHs are incorporated into plants are by foliar uptake, dry or humid deposition, with dry deposition being more common. Because PAHs are hydrophobic, root absorption is not thought to be an effective way for plants to incorporate them. The volatilization of PAHs from polluted soil can also result in foliar uptake. European Food Safety Authority (EFSA) maximum allowable limit. The European Food Safety Authority (EFSA) has established a maximum allowable limit of 0.54 to 1.5 µg/kg for the total of 15 PAH compounds found in vegetables (Dacal et al., 2021) [15]. With limited evidence of petrogenic origins, the current study concludes that incomplete combustion of recent and fossil organic matter (of pyrolytic origin) at high temperatures is the primary source of PAHs in the examined area. The primary causes of pyrolytic PAHs include industrial discharges, atmospheric deposition, and land runoff waters (Djomo et al., 2006) [16]. Generally speaking, the PAHs that have accumulated in agricultural soils and vegetables might originate from a variety of sources, including fuel combustion emissions, industrial emissions, and human activity. Additionally, the application of fertilizers and pesticides to boost productivity, as well as the burning of biomass and agricultural waste, contributed to a high level of contamination of agricultural fields. The growing demand for food has led to the expansion and intensification of agricultural systems. Environmental pollution loads have increased as a result of the overuse and abuse of agrochemicals, water, animal feed, and medications intended to boost productivity (Roozbahani et al., 2015) [17]. When compared to other agricultural systems in other nations, the level of PAH contamination in the vegetables in this study is moderate. It was discovered that the substantial aromatic proportion of the organic matter was primarily responsible for the high partitioning of PAHs to sedimentary organic matter. They viewed the organic matter as a naturally occurring "heterogeneous polymer" in which PAHs interact more positively with the aromatic areas [17].

The origin of PAHs was indicated by the Flu/Pyr ratio, one of several diagnostic ratios for PAH concentration that have been utilized to identify and quantify the contribution of each source of pollution to the designated environmental zones.

Coal and wood combustion produced (flu/pyr) ratios of 0.013 and 0.042, respectively. If the ratio of (flu/pyr) < 1 was ascribed to petrogenic sources, and if the ratio of (flu/pyr) > 1 is associated with pyrolytic origin. In the current investigation, all sites showed a Flu/Pyr ratio < 1, indicating a petrogenic origin, whereas crude oil and fuel oil had values between 0.6 and 0.9. In the study areas (EL-fatiah, EL-fatiah 2, Ain mara, and Sidi Khalid 1), the ratio of major combustion specific compounds (∑COMB = Flu, Pyr, BaA, Chr, BbF, BkF, BaP, InP, and BghiP) to the total PAHs (∑COMB / ∑PAHs) was 0.73, 0.82, 0.86, and 0.81 for the vegetables (tomato, pepper, eggplant, and zucchini), respectively [10].

The most powerful carcinogenic PAH, benzo(a)pyrene (BaP), and the total of six carcinogenic PAHs (∑PAHsCARC = Flu, Pyr, BbF, BkF, BaP, and BghiP) for the species under study were listed in Table 5. Because physical and biogeochemical processes interact to change PAH profiles during transport and flux processes, it is important to utilize the predicted diagnostic isomeric ratios of PAHs with caution. Molecular indices based on ratios of certain isomers of PAH concentrations can be used to distinguish between the fingerprints of PAHs from petrogenic or pyrolytic origins [11].

***Received**: 11-06-2025 - **Accepted**: 06-08-2025 - **Published**: 16-08-2025*

Analytical Characteristics of the Method Used in PAHs Analysis

The GC-MS equipment was employed for the study of the prioritized PAHs. Prior to evaluating the samples, this technique is based on various stages, i.e., sampling, drying, isolating from the matrix, purification, concentration, and quantitative and qualitative analysis. With the exception of the lettuce sample, the chromatogram peaks of PAHs in all samples indicate that anthracene is the greatest peak (Table 3).

Table 3. peaks of the target compounds' analytical chromatography in every sample.

Compound	Concentration
Acenaphthylene	8.87
Fluorene	10.92
Phenanthrene	14.39
Anthracene	14.57
Pyrene	20.63
Benzo(a)anthracene	26.02
Chrysene	26.20
Benzo(b)fluoranthene	30.87
Benzo(k)fluoranthene	30.89
Benzo(a)Pyrene	32.12
Indeno(1,2,3-cd)pyrene	36.33
Dibenzo(a,b)anthracene	36.42

The potential for several contamination sources to coexist and the information processes that PAHs may undergo in the air, water, or wastes prior to deposition in the sediments under study make it challenging to identify the origins of PAHs. certain chemicals may have similar evolution kinetics that might be utilized to pinpoint the source of organic matter in the environment. The sources of production, the chemical makeup, and the temperature at which the organic matter burns all affect the distributions of aromatic compounds. Fossil fuels contain pyrene, phenanthrene, and benzo(b)fluoranthene, some of which are produced after combustion. Both catalysts and non-catalysts, as well as cars, commonly emit benzo(a)pyrene. Natural gas and diesel combustion commonly produce both chrysene and benzo(a)anthracene [11-12].

The ratios of individual PAH compounds based on oil peculiarities in PAH composition and distribution pattern as a function of the emission source can also be used to identify the sources of PAHs (Gschwend and Bites, 1981; Colombo et al., 1989). Pyrolytic contamination is the term used if the source is fuel combustion, and petrogenic contamination is the term used if the source is crude oil. Previous workers had used ratio values like (Phe/Ant) and (Flu/Pyr). When these two ratios are studied simultaneously, two distinct groups of sediments can be identified: Flu/Pyr <1 for petrogenic inputs and Phe/Ant >10 for petrogenic inputs [10].

Since phenanthrene is a more thermodynamically stable tricyclic aromatic isomer than anthracene, it is frequently found in petroleum in greater concentrations than anthracene. Accordingly, a Phe/Ant ratio is found to be low in situations of pyrolytic contamination but extremely high in petrogenic pollution caused by PAHs.

The Phe/Ant ratio of crude oil was approximately 50, while that of motor vehicle exhaust was approximately four. Low Phe/Ant ratio values (less than 10) suggested that the primary source of PAHs was the burning of fossil fuels proposed that sediments with Phe/Ant > 10 were primarily contaminated by petrogenic inputs, while Phe/Ant < 10 were typical of pyrolytic sources. Low Phe/Ant ratios (< 10) were detected in all regions in vegetable samples in the current study, suggesting that the sources of PAH contamination may differ. The ratio of specific PAH components varied between vegetable samples (Table 4). indicating that they were PAHs produced from pyrolysis. Nevertheless, the various Phe/Ant ratio values may be associated with weathering processes like photo-, chemical-, or bio-degradation, as well as the composition (for vegetable samples). The Flu/pyr ratio can indicate the source of PAH since. The majority of the samples in this study had Flu/pyr ratio values below 1. The Phe/Ant and Flu/Pyr ratio data, however, showed a heterogeneous pattern of pyrolytic contamination for the majority of vegetable samples. (Table 4).

The ratio of low molecular weight to high molecular weight compounds indicates that polyaromatic hydrocarbon compounds with two to three rings represent low molecular weight, while those with four to five rings represent high molecular weight. In all stations for vegetable samples, the ratio of (LMW/HMW) (Naphthalene + Acenaphthylene + Acenaphthene + Fluorene + Phenanthrene + Anthracene / Fluoranthene + Pyrene + Benzo(a)anthracene + Chrysene + Benzo(b)fluoranthene + Benzo(k)fluoranthene +

Benzo(a)pyrene + Dibenzo(a,h)anthracene + Benzo(ghi)Perylene + Indeno(1,2,3-cd)Pyrene) was less than 1, indicating that the source of PAHs was of pyrolytic origin.

Table 4. Poly aromatic hydrocarbon diagnostic ratios in fruiting vegetable samples (zucchini, eggplant, pepper, and tomato)

Ratio Species	(Flu/Pyr)	∑COMB	∑COMB /PAHs	(Phe/Ant)	$\sum PAH_{CARC}$	(LMW/ HMW)
Tomato	2.739	6.038	0.73	1.29	1.484	0.25
Pepper	2.814	6.739	0.82	1.30	1.487	0.26
Eggplant	2.760	6.719	0.86	1.25	1.477	0.24
Zucchini	2.769	6.727	0.81	1.26	1.485	0.24

Table 5. The ratios of vegetable samples (R1–R6).

Ratio species	R1	R2	R3	R4	R5	R6
Tomato	1	0.732	0.580	0.564	1.02	0.469
Pepper	1	0.738	0.592	0.564	1.02	0.435
Eggplant	1	0.733	0.589	0.556	1.02	0.531
Zucchini	1	0.734	0.585	0.558	1.02	0.441

Generally, many studies on environmental impacts on the aquatic, soil, air, food, plants, and other samples were given importance in Libya. Where the determination of heavy metals, petroleum compounds, pesticides, radioactive, and toxic compounds was carried out [18 -45]. Most of these studies concluded that the human activities during 20 and 21st centuries were directly affecting the pollution of these samples [46 -86].

Conclusion

Based on the findings of this investigation, many kinds and compounds of polycyclic aromatic hydrocarbons were found in the chosen samples, indicating the origin and dispersion of these hydrocarbons. Numerous factors, such as the compounds' production and environmental dispersal, may influence the measured values when identifying the source of PAHs in agricultural fields. Because the uptake of toxins depends on the pollution source to which it is exposed, environmental factors might have an impact on the pattern of accumulation in the soil. The findings demonstrated that, mostly based on their place of origin, there are relative differences in the hydrocarbon molecules between locations. In general, pyrolytic and petrogenic sources account for the majority of the hydrocarbon compounds found in the samples from the examined area. Although the general public is most commonly exposed to polycyclic aromatic hydrocarbons (PAHs) through food, information on possible exposure to PAHs is of particular interest due to the highly immunotoxic and carcinogenic effects of these compounds on human health, regardless of the pathways of such accumulation.

Acknowledgment

Conflict

References

1. Food and Agriculture Organization (FAO), World Food Programme (WFP). Food security in Libya – an overview agriculture and rural livelihoods assessment-Libya. Rome: FAO; 2011.
2. Hwang H, Wade T, Sericano J. Concentrations and source characterization of polycyclic aromatic hydrocarbons in pine needles from Korea, Mexico, and United States. Atmos Environ. 2003;37(16):2259-2267.
3. Islam M, Mohammad Z, Mustafizur R, Afroz N, Sirajum M. Effect of industrial effluents on germination of summer leafy vegetables. Int Res J Earth Sci. 2015;3(1):[page range].
4. Hussain RO, Mohammed DA. Heavy metals status in vegetables and soil irrigated with wastewater in Domiz1 Camp, Duhok, Kurdistan Region-Iraq. Duhok: Directorate of the Environment of Duhok City; 2020.
5. Chen L, Ran Y, Xing B, Mai B, He J, Wei X. Contents and sources of polycyclic aromatic hydrocarbons and organochlorine pesticides in vegetable soils of Guangzhou, China. Chemosphere. 2005;60(7):879-890.
6. Dacal A, Berriel C, Díaz R, Suárez M, Zumbado M, Hernández L, et al. Validation of a method scope extension for the analysis of POPs in soil and verification in organic and conventional farms of the Canary Islands. Toxics. 2021;9(5):101.
7. Girelli A, Anna M, Francesca T. Determination of polycyclic aromatic hydrocarbons in tea infusion samples by high-performance liquid chromatography with fluorimetric detection. J Food Qual. 2017;[volume(issue)]:[page range].

8. Camargo M, Toledo M. Polycyclic aromatic hydrocarbons in Brazilian vegetables and fruits. Food Control. 2003;14(1):49-53.
9. Hamad IH, Nuesry MS. The polycyclic hydrocarbons levels in some fishes tissues collected from Derna City (Libya) Coast. Int Conf Chem Agric Med Sci. 2014:52-56.
10. Hamad MAH, Mounera AAE, Baseet ESM, Eman E, Al-Badri M. Identification and detection the aromatic and aliphatic hydrocarbons in Epinephelus marginatus fish samples collected from Benghazi Coast. Int J Adv Multidiscip Res Stud. 2023;6(3):107-113.
11. Mohammed A, Hamad MAH, Mounera AAE, Eman IHE. Extraction and identification of aliphatic hydrocarbons in marine sediment samples at Benghazi city and Dyriana town coasts (Libya). J Res Humanit Soc Sci. 2023;11(10):168-174.
12. Hasan MAH, Muftah HS, Abdelghani KA, Saad SI. Poly aromatic hydrocarbon concentrations in some shell samples at some Tobrouk city coast regions: could the oil industry be significantly affecting the environment? Ukr J Ecol. 2022;12(3):21-28.
13. Mobegi EK, Nyambaka H, Nawiri MP. Physico-chemical characteristic and levels of polycyclic aromatic hydrocarbons in untreated water from Ngong River, Kenya. J Pollut Eff Control. 2016;4:163.
14. Yunker MB, McDonald RW, Vingarzan R, Mitchell RH, Gyotte D, Sylvestre S. PAHs in the Fraser River basin: a critical appraisal of PAH ratios as indicators of PAH source and composition. Org Geochem. 2002;33(4):489-515.
15. Zohair A. Levels of poly aromatic hydrocarbons in Egyptian vegetables and their behavior during soaking in oxidizing agent solutions. World J Agric Sci. 2006;2(1):90-94.
16. Djomo JE, Garrigues P, Narbonne JF. Uptake and depuration of polycyclic aromatic hydrocarbons from sediment by the zebrafish (Brachydanio rerio). Environ Toxicol Chem. 1996;15(7):1177-1181.
17. Roozbahani M, Sobhanardakani S, Karimi H, Sorooshnia R. Natural and anthropogenic source of heavy metals pollution in the soil samples of an industrial complex; a case study. Iran J Toxicol. 2015;9(29):1336-1341.
18. Habel AMA, Mohamed NIH, Mohammed MA, Hamad MAH. The levels and sources of aliphatic and polycyclic aromatic hydrocarbons in blue runner fish from Benghazi Coast, Libya. Afr J Biol Sci. 2024;6(3):[page range].
19. Hasan HMI, Mohamad ASA. A study of aliphatic hydrocarbons levels of some waters and sediments at Al-Gabal Al-Akhder coast regions. Int J Chem Sci. 2013;11(2):833-849.
20. Siddiqui AA, Mojahid I, Hasan HH. Synthesis and antituberculostic activity of some novel 1,3,4-oxadiazole. Hamdard Medicus. 2011;54(1):82-89.
21. Eltawaty SA, Abdalkader GA, Hasan HM, Houssein MA. Antibacterial activity and GC-MS analysis of chloroform extract of bark of the Libyan Salvia fruticosa Mill. Int J Multidiscip Sci Adv Technol. 2021;1(1):715-721.
22. Aljamal MA, Hasan HM, Al Sonosy HA. Antibacterial activity investigation and antibiotic sensitivity for different solvents (ethanol, propanol, DMSO and diethyl ether) extracts of seeds, leaves and stems of (Laurus azorica and Avena sterilis) plants. Int J Curr Microbiol Appl Sci. 2024;13(11):175-190.
23. Hamade MH, Abdelraziq SA, Gebreel AA. Extraction and determination of beta-carotene content in carrots and tomato samples collected from some markets at ElBeida City, Libya. EPH Int J Appl Sci. 2019;1(1):105-110.
24. Hasan HM, Ibrahim H, Gonaid MA, Mojahidul I. Comparative phytochemical and antimicrobial investigation of some plants growing in Al Jabal Al-Akhdar. J Nat Prod Plant Resour. 2011;1(1):15-23.
25. Hasan H, Jadallah S, Zuhir A, Ali F, Saber M. The anti-cancer, anti-inflammatory, antibacterial, antifungal, anti-oxidant and phytochemical investigation of flowers and stems of Anacyclus clavatus plant extracts. AlQalam J Med Appl Sci. 2025:[page range].
26. Hasan H, Zuhir A, Shuib F, Abdraba D. Phytochemical investigation and exploring the Citrullus colocynthis extracts as antibacterial agents against some Gram-positive and negative bacteria species. AlQalam J Med Appl Sci. 2025:[page range].
27. MdZeyaullah RA, Naseem A, Badrul I, Hamad MI, Azza SA, Faheem AB, et al. Catechol biodegradation by Pseudomonas strain: a critical analysis. Int J Chem Sci. 2009;7(3):2211-2221.
28. El-Mehdawy MF, Eman KS, Hamad MIH. Amino acids contents of leaves and stems for two types of herbal plants (Marjoram and Hybrid tea rose) at AL-Gabal AL-Akhder region. Der Pharma Chem. 2014;6(6):442-447.
29. Gonaid MH, Hamad HH, Ibrahim HH, Mojahidul I. Comparative phytochemical and antimicrobial investigation of some plants growing in Al Jabal Al-Akhdar. J Nat Prod Plant Resour. 2011;1(1):15-23.
30. El-Mehdawy MF, Eman KS, Hamad MIH. Amino acid contents of leaves and stems for three types of herbal plants at Al-Gabal Al-Akhder region. World J Chem. 2014;9(1):15-19.
31. Hamad MH, Noura AAM, Salem AM. Phytochemical screening, total phenolic, anti-oxidant, metal and mineral contents in some parts of Plantago albicans grown in Libya. World J Pharm Res. 2024;13(3):1-17.
32. Anees AS, Hamad MIH, Mojahidul I. Antifungal potential of 1,2,4-triazole derivatives and therapeutic efficacy of Tinea corporis in albino rats. Der Pharma Lett. 2011;3(1):228-236.
33. Hamad H, Marwa M, Amal H. Determining the contents of antioxidants, total phenols, carbohydrate, total protein, and some elements in Eucalyptus gomphocephala and Ricinus communis plant samples. Libyan Med J. 2015;[volume(issue)]:222-231.
34. Hamad H, Zuhir A, Farag S, Dala A. Efficiency of Cynara cornigera fruits on antibacterial, antifungal and its phytochemical, anti-oxidant screening. Libyan Med J. 2025:[page range].
35. Hanan MA, Hamida E, Hamad MAH. Nitrogen, phosphorus and minerals (sodium, potassium and calcium) contents of some algae species (Anabaena and Spirulina platensis). Int J Curr Microbiol Appl Sci. 2016;5(11):836-841.

***Received**: 11-06-2025 - **Accepted**: 06-08-2025 - **Published**: 16-08-2025*

36. Hasan H, Mariea FFE, Eman KS. The contents of some chemical compounds of leaves and stems of some herbal plants (Thyme, Rosemary, Salvia, Marjoram and Hybrid Tea Rose) at Al-Gabal Al-Akhder region. EPH Int J Appl Sci. 2014;6(3):[page range].
37. El-Mehdawe MF, Eman KS, Hamad MIH. Heavy metals and mineral elements contents of leaves and stems for some herbal plants at AL-Gabal AL-Akhder region. Chem Sci Rev Lett. 2014;3(12):980-986.
38. Hamad H, Ashour S, Ahmed A. Estimation of amino acid composition, total carbohydrate, and total protein content in Ballota pseudodictamnus plant extracts from Al Jabal Al Akhdar Region, Libya. Libyan Med J. 2015:[page range].
39. Hamad H, Ahmed H, Wafa A. Evaluation of anti-oxidant capacity, total phenol, metal, and mineral contents of Ziziphus lotus plant grown at some regions of AlGabal AlKhder, Libya. Libyan Med J. [year];[page range].
40. Hesien RA, Amira AKA, Ahlaam MA, Hamad MAH. Determination the anti-oxidant capacity, total phenols, minerals and evaluation the anti-bacteria activity of leaves and stems of gaper plant extracts. Sch J Appl Med Sci. 2024;12(4):451-457.
41. Hamad MAH, Noura AAM, Salem AM. Total carbohydrate, total protein, minerals and amino acid contents in fruits, pulps and seeds of some cultivars of muskmelon and watermelon fruit samples collected from Al. Der Pharma Chem. 2024;16(3):330-334.
42. Ben Arous NAA, Naser ME, Hamad MAH. Phytochemical screening, anti-bacterial and anti-fungi activities of leaves, stems and roots of C. parviflorus Lam and C. salviifolius L plants. Int J Curr Microbiol Appl Sci. 2014;13(11):262-280.
43. Anas FAE, Hamad MAH, Salim AM, Azza MH. Phytochemical screening, total phenolics, antioxidant activity and minerals composition of Helichrysum stoechas grown in Libya. Afr J Biol Sci. 2024;3(6):[page range].
44. Naseer RE, Najat MAB, Salma AA, Hamad MAH. Evaluation of metal and mineral contents of leaves, stems and roots of C. parviflorus Lam and C. salviifolius L plants growing at Al Ghabal Al-Khder (Libya). Int J Adv Multidiscip Res Stud. 2024;4(5):191-194.
45. Hamad MAH, Salem AM. Total carbohydrate, total protein, minerals and amino acid contents in fruits, pulps and seeds of some cultivars of muskmelon and watermelon fruit samples collected from Algabal Alkhder region. Sch J Appl Med Sci. 2024;12(1):1-7.
46. Haroon A, Hamad MAH, Wafa AAS, Baseet ESM. A comparative study of morphological, physiological and chemical properties of leaves and stem samples of (E. gomphocephala) (Tuart) plant growing at coastal (Derna city) and... J Res Environ Earth Sci. 2024;9(12):10-18.
47. Enam FM, Wesam FAM, Hamad MAH. Detection the contents of minerals of (sodium, potassium and calcium) and some metals of (iron, nickel and copper) in some vegetable and soil samples collected from Al-Marj. Int J Adv Multidiscip Res Stud. 2023;5(3):304-309.
48. Rinya FMA, Hamad MAH, Ahlam KA, Hammida MEH. Phytochemical screening of some herbal plants (Menthe, Origanum and Salvia) growing at Al-Gabal Al-akhder Region-Libya. Afr J Basic Appl Sci. 2017;9(3):161-164.
49. Ali RFA, Hamad MAH, Ahlam KA, Hammida MEH. Phytochemical screening of some herbal plants (Menthe, Origanum and Salvia) growing at al-gabal al-akhder region-Libya. Int J Pharm Life Sci. 2017;8(4):5500-5503.
50. Abdelrazeg A, Khalifa A, Mohammed H, Miftah H, Hamad H. Using melon and watermelon peels for the removal of some heavy metals from aqueous solutions. AlQalam J Med Appl Sci. 2025:[page range].
51. Abdul Razaq A, Hamad H. Estimate the contents and types of water well salts by the Palmer Roger model affecting the corrosion of Al-Bayda city (Libya) network pipes. AlQalam J Med Appl Sci. 2025:[page range].
52. Abdulsayid FA, Hamad MAH, Huda AE. IR spectroscopic investigation, X-ray fluorescence scanning, and flame photometer analysis for sediments and rock samples of Al-Gabal Al-Akhder coast region (Libya). IOSR J Appl Chem. 2021;14(4):20-30.
53. Alambarki M, Hasan HMA. Assessment of the heavy metal contents in air samples collected from the area extended between Albayda and Alquba cities (Libya). AlQalam J Med Appl Sci. 2025:[page range].
54. Al-Nayyan N, Mohammed B, Hamad H. Estimate of the concentrations of heavy metals in soil and some plant samples collected from (near and far away) of the main road between Al-Bayda city and Wadi Al-Kouf region. AlQalam J Med Appl Sci. 2025:[page range].
55. Hasan HMI. Studies on physicochemical parameters and water treatment for some localities along coast of Alexandria [PhD thesis]. Alexandria: Alexandria University; 2006.
56. Hamad MAH, Hager AA, Mohammed EY. Chemical studies of water samples collected from area extended between Ras Al–Halal and El Haniea, Libya. Asian J Appl Chem Res. 2022;12(3):33-46.
57. Hamad M. Studies on physicochemical parameters and water treatment for some localities along coast of Alexandria. Alexandria: Alexandria University; 2006.
58. Hamad M, Mohammed AA, Hamad MAH. Adsorption and kinetic study for removal some heavy metals by use in activated carbon of sea grasses. Int J Adv Multidiscip Res Stud. 2024;4(6):677-685.
59. Hamad MAH, Hamad NI, Mohammed MYA, Hajir OAA, Al-Hendawi RA. Using bottom marine sediments as environmental indicator state of (Tolmaitha – Toukra) region at eastern north coast of Libya. Sch J Eng Technol. 2024;2(14):118-132.
60. Hamad MIH. The heavy metals distribution at coastal water of Derna city (Libya). Egypt J Aquat Res. 2008;34(4):35-52.
61. Hamad MIH, Mojahidul I. The concentrations of some heavy metals of Al-Gabal Al-Akhdar coast sediment. Arch Appl Sci Res. 2010;2(6):59-67.

Received*: 11-06-2025 -* ***Accepted****: 06-08-2025 -* ***Published****: 16-08-2025*

62. Hamad MAH, Amira AKA. Estimate the concentrations of some heavy metals in some shoes polish samples. EPH Int J Appl Sci. 2016;2(2):24-27.
63. Hamad MAH, Hussien SSM, Basit EEM. Accumulation of some heavy metals in green algae as bio indicators of environmental pollution at Al-Haniea region: Libya coastline. Int J Adv Multidiscip Res Stud. 2024;4(5):188-190.
64. Hamad MIH, Ahmed MA. Major cations levels studies in surface coastal waters of Derna city, Libya. Egypt J Aquat Res. 2009;35(1):13-20.
65. Hamad MIH, Yahiya AI, Hassan SS, Salama MM. Biological study of transition metal complexes with adenine ligand. Proceedings. 2019;41(1):77.
66. Hamad MIH, Masoud MS. Thermal analysis (TGA), diffraction thermal analysis (DTA), infrared and X-rays analysis for sediment samples of Toubrouk city (Libya) coast. Int J Chem Sci. 2014;12(1):11-22.
67. Hamad R, Ikraiam FA, Hasan H. Estimation of heavy metals in the bones of selected commercial fish from the eastern Libyan coast. J Rad Nucl Appl. 2024;9(1):47-51.
68. Hasan HAH. Estimate lead and cadmium contents of some archeological samples collected from ancient cities location (Cyrene and Abolonia) at Al-Gabal Al-Akhder Region, Libya. Univ J Chem Appl. 2021;12(21):902-907.
69. Hasan HMI. Studies on physicochemical parameters and water treatment for some localities along coast of Alexandria [PhD thesis]. Alexandria: Alexandria University; 2006.
70. Hasan JA, Hasan HMA. Potential human health risks assessment through determination of heavy metals contents in regularly consumed yogurta in Libya. World J Pharm Pharm Sci. 2024;13(12):100-112.
71. Mamdouh SM, Wagdi ME, Ahmed MA, Alaa EA, Essam AM, Hamad MIH. Rice husk and activated carbon for waste water treatment of El-Mex Bay, Alexandria Coast, Egypt. Arab J Chem. 2016;9(Suppl 2):S1590-S1596.
72. Mamdouh SM, Wagdi ME, Ahmed MA, Alaa EA, Hamad MIH. Heavy metals accumulation in sediments of Alexandria coastal areas. Bull Fac Sci. 2012;47(1-2):12-28.
73. Mamdouh SM, Wagdi ME, Ahmed MA, Hamad MIH. Chemical studies on Alexandria coast sediment. Egypt Sci Mag. 2005;2(4):93-102.
74. Mamdouh SM, Wagdi ME, Ahmed MA, Alaa EA, Hamad MIH. Distribution of different metals in coastal waters of Alexandria, Egypt. Egypt Sci Mag. 2010;7(1):1-19.
75. Mohamed AE, Afnan SA, Hamad MA, Mohammed AA, Mamdouh SM, Alaa RE, et al. Usage of natural wastes from animal and plant origins as adsorbents for the removal of some toxic industrial dyes and heavy metals in aqueous media. J Water Process Eng. 2023;55:[page range].
76. Mohamed HB, Mohammed AZ, Ahmed MD, Hamad MAH, Doaa AE. Soil heavy metal pollution and the associated toxicity risk assessment in Ajdabiya and Zueitina, Libya. Sci J Damietta Fac Sci. 2024;14(1):16-27.
77. Nabil B, Hamad H, Ahmed E. Determination of Cu, Co and Pb in selected frozen fish tissues collected from Benghazi markets in Libya. Chem Methodol. 2018;2:[page range].
78. Wesam FAM, Hamad MAH. Detection of heavy metals and radioactivity in some bones of frozen chicken samples collected from Libyan markets. Int J Adv Multidiscip Res Stud. 2023;3(3):761-764.
79. Wesam FAM, Hamad MAH. Study the accumulation of minerals and heavy metals in Ulva algae, Cladophora, Polysiphonia and Laurencia algae samples at eastern north region of Libya coast. GSC Biol Pharm Sci. 2023;23(3):147-152.
80. Alaila AK, El Salhin HE, Ali RF, Hasan HM. Phytochemical screening of some herbal plants (Menthe, Origanum and Salvia) growing at al-gabal al-akhder region-Libya. Int J Pharm Life Sci. 2017;8(4):[page range].
81. Elsalhin H, Abobaker HA, Hasan H, El-Dayek GA. Antioxidant capacity and total phenolic compounds of some algae species (Anabaena and Spirulina platensis). Sch Acad J Biosci. 2016;4(10):782-786.
82. Ahmed O, Ahmed NH, Hamad MAH, Fatin ME. Chemical and biological study of some transition metal complexes with guanine as ligand. Int J New Chem. 2023;10(3):172-183.
83. Hamad H, Zuhir A, Farag S, Dala A. Efficiency of Cynara cornigera fruits on antibacterial, antifungal and its phytochemical, anti-oxidant screening. Libyan Med J. 2025:[page range].
84. Alfutisi H, Hasan H. Removing of thymol blue from aqueous solutions by pomegranate peels. EPH Int J Appl Sci. 2019;1(1):111-119

***Received**: 11-06-2025 - **Accepted**: 06-08-2025 - **Published**: 16-08-2025*