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Introductory Chapter: Sources, Health Impact, and Environment Effect of Hydrocarbons

Muharrem Ince and Olcay Kaplan Ince

1. Introduction

Pollution control and environmental protection have become a worldwide issue of concern. The aliphatic hydrocarbons (AHs), aromatic hydrocarbons (ArHs) such as benzene and toluene, and polycyclic aromatic hydrocarbons (PAHs), including benzo[*a*]anthracene, benzo[ghi]pyrene, and benzo[*a*]pyrene, are persistent organic pollutants (POPs) for ecosystem. These hazardous pollutants are risky because of mutagenic, carcinogenic, immunotoxic, and teratogenic effects. These components threaten all life forms ranging from microorganisms to humans when they are released into the environment especially via human activities. The aim of this study is to provide up-to-date information on the various hydrocarbons present in the environment, routes of exposure, and their adverse impact on environment and human health. There are two major categories that contain hydrocarbons; these are aliphatic and aromatic compounds (**Figure 1**). While aromatic hydrocarbons contain at least one benzene ring, the other group called as nonaromatic or aliphatic does not contain it. The basic structure that forms aromatic hydrocarbons is the benzene ring. On the other hand, petroleum hydrocarbons (PHCs) comprised of carbon and hydrogen atoms which are organic compounds. They have varying structural configurations with physical and chemical characteristics. They can be broadly classified as gasoline range organics (GROs) and diesel range organics (DROs). The first group that is called GROs comprises monoaromatic hydrocarbons including toluene, benzene, and ethylbenzene. This category has short-chain alkanes ranging from 6 to 10 C. The second group that is called DROs has longer C-chain alkanes from 10 to 40 C, and this category contains hydrophobic chemicals including polycyclic aromatic hydrocarbons (PAHs) [1, 2]. These compounds, in contaminated ecosystem, are considered to be one of the most stable hydrocarbon forms. The PAH molecular weight is the main factor to determine their origin's level in earth. There are two PAH sources: natural and anthropogenic. Both sources are important and remarkable. Because of natural and anthropogenic activities, these pollutants are irregularly distributed throughout various levels and locations to all over the world. Various studies have revealed that PAHs have carcinogenic, teratogenic, and mutagenic effect on human health [3, 4]. The main skeleton of these compounds, classified as organic pollutants, consists of two or more benzene rings. The extensive nonpolar contaminants are detected in petrochemical products including coal, oil, and tar. Another significant source of hydrocarbons is also incomplete combustion [5–8]. According to researchers, because of ecotoxicological risks and potential sources, 26 AHs and 16 PAHs causing concerns for ecosystem are categorized as carcinogen or mutagen by the United States Environmental Protection Agency (USEPA). These ecotoxicological compounds include benzo[*a*]pyrene, benz[*a*]anthracene, etc.

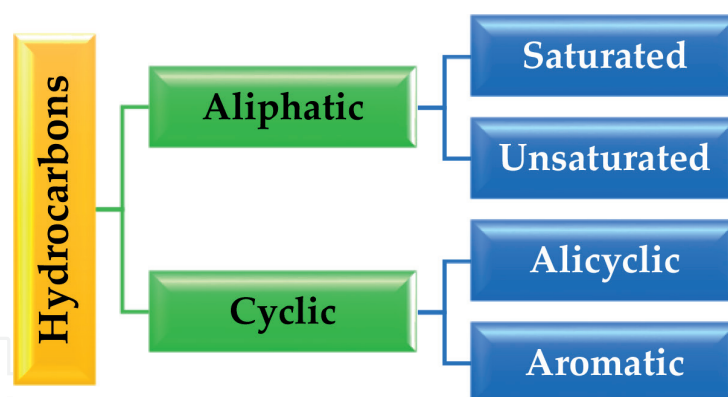


Figure 1.
Hydrocarbon classification [42].

The USEPA mentioned that there are 126 major pollutants in the environment, 25 of them were threatening and 5 were extremely dangerous for the environment. For example, some health institutions including the USEPA and International Agency for Research on Cancer (IARC) mentioned that benzo[*a*]pyrene that is a member of PAHs is carcinogenic for animals and humans [7, 9–11].

2. Sources of hydrocarbons

The major hydrocarbon sources are petroleum and petroleum combustion; however, their emission sources can be classified as phytogenic (natural), petrogenic, and pyrogenic. To recognize pollutant type and migration, circumstances play a key role for their origin [12]. Hydrocarbons can enter to the environment via dispersion, evaporation, dissolution, adsorption, and other processes including petroleum and petroleum combustion [13, 14]. Petrogenic sources generally pollute ground-water and threaten the environment because petrogenic source products including lubricants and fuels leak from the tanks and release into the environment [15]. The USEPA specified 16 priority PAHs in a petroleum source, namely, alkylated naphthalene, dibenzothiophene, fluorene, phenanthrene, and chrysene series [16]. The pyrogenic PAHs are produced during the fuel combustion because there are suitable conditions that are high temperature and absence of oxygen. Also, pyrolysis of fat and incomplete combustion besides power plants are the most prominent hydrocarbon sources [17]. Hydrocarbons and their derivatives are a significant environmental concern due to their extensive use and toxic mechanism action, and these products are highly available in aquatic medium [18, 19]. Industrial activities and chemical plants produce PAHs, and they are considered as petrogenic and natural PAH sources [20]. During fat pyrolysis and incomplete combustion processes, anthropogenic emissions of PAHs are released into the environment [7, 8]. On the other hand, PAH sources were classified as natural, industrial, domestic, agricultural, and mobile by Ravindra et al. [21]. Hydrocarbons are usually generated by various sources including wildfires, oil seepages, volcanic activities, and other sources. Moreover, these natural hydrocarbons are mainly produced during organic material chemical conversions in microorganisms, fungi, plants, sediments, etc. [16, 22–24].

3. Health threat and environmental impact assessment

Recent studies have recognized the effects of toxicity, mutagenicity, and carcinogenicity of hydrocarbons. Increasing contamination level of these pollutants

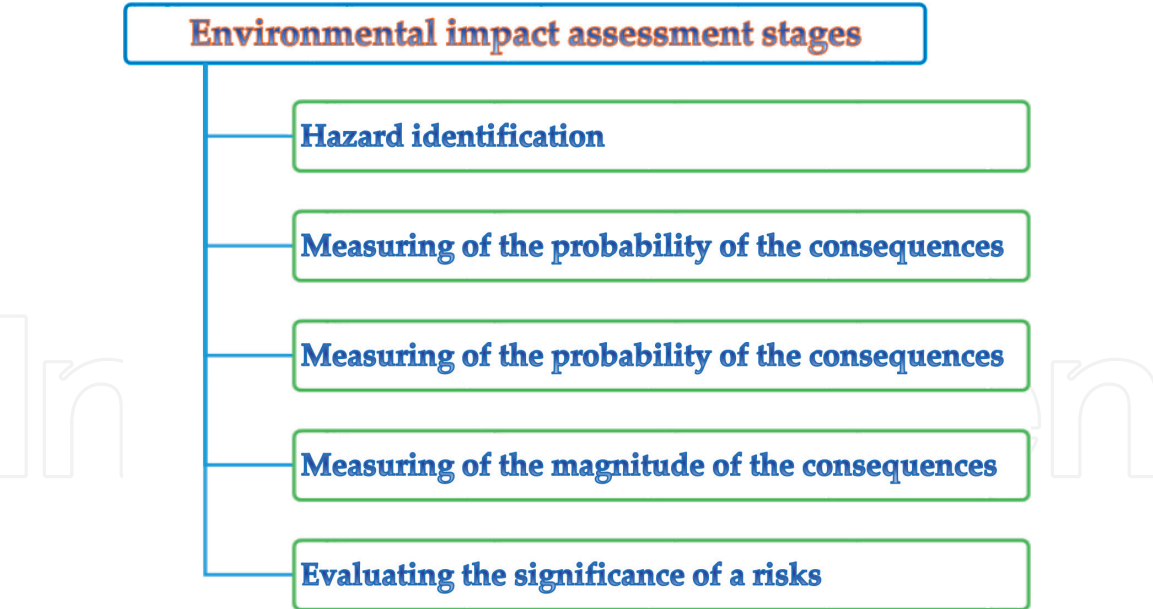


Figure 2.
Environmental impact assessment stages.

in environment especially in aquatic media is a significant environmental concern because they are used frequently and show environmental toxic effects [25–28]. The USEPA and World Health Organization (WHO) classified PAHs and total petroleum hydrocarbons (TPHs) as POP groups in marine and coastal environment [29, 30]. The most of PAHs have been banned by health authorities due to their long half-life, wide distribution, and high bioaccumulation in the food chain, as well as their potential for toxicity to humans, because these compounds are highly lipid soluble and these toxic chemicals can bioaccumulate from environment to the gastrointestinal tract of mammals [25, 31]. When animals and humans are exposed to hydrocarbons, it is probable that they have various health problems because they are vulnerable and endangered against these components. Research on some hydrocarbons including benzo[*a*]pyrene, pyrene, and benzo[*a*]anthracene have revealed that these compounds have carcinogenic and mutagenic effect [7, 8, 11, 32, 33]. During certain time frameworks and under given conditions, assessment of environmental impact is a very important systematic process. To measure the actual or potential impacts including psychosocial, physical, microbiological, and chemical hazard on the health case of humans or environment has a vital role [34–36]. After the obtained series of critical data from monitoring studies, quantitative environmental impact assessment (EIA) can be made. To provide better view for evaluating POP exposure and their adverse health effect on environment and human requires critical data obtained from the environment [37–39]. The EIA has several key stages, and it covers the risk level of all types of ecosystems. These stages are summarized in **Figure 2**. The EIA includes all activities which attempt to analyze and evaluate the effects of human stresses on natural and anthropogenic environments [36, 40–43].

4. Conclusion and future perspectives

The main aim of this study is to provide contemporary information on a variety of hydrocarbons present in the environment, exposure routes, and their adverse effects on ecosystem. Hydrocarbon sources, human health impact, and effect on the environment have been thoroughly investigated and presented. In light of this information, generated by natural or anthropogenic sources, hydrocarbons’ mutagenic, teratogenic, and carcinogenic characteristics have caused serious concerns

in today's environment; thus, various remediation techniques are needed to remove these hazardous chemicals from the environment. Therefore, some suggestions were presented as:

- All health authorities should develop standard methods for analysis of hydrocarbons and share it for all researchers.
- Researchers should develop more various remediation techniques available for hydrocarbons, and they should be applicable on every aspect of the environment such as soil, water, and air.
- After the treatment process, developed remediation techniques should not leave behind any second pollutant.
- Ecological risk assessment should be evaluated using the risk quotient.
- Techniques for removing hydrocarbons from the environment should be developed, but it is important that preventive measures can be taken to prevent these pollutants from entering the food chain and environment.

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