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Polycylic Aromatic Hydrocsbons as Hazardous Pollutant: Sources, Impact on the Environment and Human Health, Monitoring and Preventive Strategies

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Abstract
Polycyclic aromatic hydrocarbons (PAHs) are organic pollutants that exhibit low solubility and high boiling points hence, contaminate the environment. This paper explores the environmental and health effects of PAHs, methods for monitoring and assessing their presence, and preventive measures to mitigate their pollution. PAHs are created when organic materials burn completely, though they may stay in the environment for an extended period of time. Human activities like industrial emissions, burning of waste, exhaust from vehicles, aero plane, smoking, gas burners, and coal cooking are the main sources of PAHs. Marine fishes, humans and invertebrates and so on has been found to be contaminated with PAHs through various routes of exposure like inhalation, food, water sediments, maternal transmission, soil and trophic transfer. These compounds have diverse effects on the environment and human health. Many researchers have focused on the carcinogenic toxicity of the pollutant. They are concentrated in worldwide and found in many African continents due to human activities and combustion processes. They enter the environment and leads to bioaccumulation in food chains and hence cause direct or indirect detrimental human health risks like cancer of (skin, breast, liver, bladders) asthma, cardiovascular illness, bronchitis and so on. Monitoring PAH level is crucial due to their widespread presence in the environment. Various techniques like mass spectrometry, high performance liquid chromatography (HPLC), toxic equivalency (TEQ), toxic equivalency factor (TEF), gas chromatography (GC), use of biomarkers, are used to evaluate and assess the danger of PAH. Additionally, preventive measures include use of ingredients with antioxidants qualities and acidic substances in cooking and marinades, use of electric or gas boilers instead of charcoal, Nanoparticle (NP)-based eco-engineered bioremediation.

Keywords: Anthropogenic, Contaminate, Environment, Food chain and Bioaccumulation.

INTRODUCTION
Polycyclic aromatic hydrocarbons (PAHs) are a type of persistent organic pollutants (POPs) that include several thousand common environmental contaminants (Premnath, 2021). The term "PAH compounds" refers to a broad class of intricate organic compounds made up of hydrogen and carbon atoms arranged in a fused ring structure with a minimum of two benzene rings. Many aromatic rings make up their structure, and two carbon atoms are shared by each ring (Sahoo *et al.,* 2020).

PAHs are created when organic materials burn incompletely hence, can be released by natural events such as volcanic eruptions and forest fires (Kozak *et al.*, 2017). But the majority of

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emissions come from human activities including burning biomass, making coke, using vehicles, heating industrial processes, and burning waste (Inceoˇglu *et al.*, 2019). The atmosphere, water, soil, sediments, and vegetation are all susceptible to contamination by polycyclic aromatic hydrocarbons (Han *et al.*, 2019).

The U.S. Environmental Protection Agency (EPA) established a list of 16 priority PAHs (often referred to as "parent PAHs") in 1976, which marked the beginning of the monitoring of polycyclic aromatic hydrocarbons in the environment, which began more than 40 years ago (Keith, 2015). Benzo[a]pyrene (B[a]P), the first chemical carcinogen identified, is the most well-known PAH (Ravindra *et al.*, 2008). According to several studies (Tiwari *et al.*, 2015), the carcinogenic potency of PAHs generally rises with the number of aromatic rings.

This review aims to provide an overview on PAHs, effects on the environment and human health, it's concentration in some countries as well as exploding various methods that can be used to monitor and assess the pollutant, prevention strategies and mitigation measures that can be taken to minimize the environmental pollution of polycyclic aromatic hydrocarbons.

SOURCES OF POLYCYCLIC AROMATIC HYDROCARBONS

Sources of PAHs resulting from production methods include diagenic (natural processes), biogenic (biological processes), petrogenic (industrial processes), and pyrogenic (combustion processes) processes (Hylland, 2006). Industrial development has significantly increased the concentration of PAHs in the environment in recent decades due to carbonaceous materials are incompletely burned during energy and industrial production processes, (Zhu *et al.*, 2019). Domestic emission sources include cooking on oil/gas burners, kerosene/wood stoves, burning wood, burning waste, coal coking, and other forms of residential heating (Ravindra *et al.*, 2008).

According to Abdel-Shafy and Mansour (2016), human activities such as traffic, thermal power plants, smoking, home heating, and industrial emissions are the main sources of PAHs. 90% of PAHs are produced by incomplete combustion and human activities like driving, cooking, and burning fossil fuels (Hung *et al.*, 2020). Krauss *et al.* (2005) connected the biological source of PAHs to the activities of bacteria, fungus, and plants producing perylene, phenanthrene, and naphthalene.

TRANSPORT MEDIUM

Food: According to studies (Shariatifar *et al.*, 2020), PAHs have been found to accumulate in a variety of food matrices, including dairy products (milk, yoghurt, butter), etc. **1.2.2 Air:** According to INCHEM (2011), PAHs are frequently discharged into the atmosphere, either directly into the air or through evaporation from soil or water. PAHs can be inhaled and cause exposure both indoors and outdoors.

Water: PAHs can be carried by storm surges and returned to suspension in the case of sediments existing in relatively shallow seas and within the depth of closure (Arienzo *et al.*, 2019), potentially reaching the beaches.

Soil: Roadside agricultural soils are a major source of persistent organic pollutants (PAHs) that can infiltrate crops and move up the food chain, endangering food safety (Yang *et al.*, 2021).

Maternal Transfer: As a result of significantly high content of PAHs in the yolk, Martins *et al.* (2020) proposed maternal transmission of PAHs.

EFFECTS OF PAHs ON THE ENVIRONMENT AND HUMAN HEALTH

EFFECTS OF PAHs ON THE ENVIRONMENT: According to Mueller and Shann (2006), the buildup of PAHs in soils can expose people directly or indirectly. In a study on the impact of polycyclic aromatic hydrocarbons (PAHs) on plants, Desalme *et al.* (2013) found that contamination happens through direct pathways (air-leaf) as well as indirect pathways (air-soil-root). Additionally, the study's experimental findings showed that PAHs have an adverse effect on plant growth, interfering with root symbioses and plant carbon allocation.

EFFECTS OF PAHs ON HUMAN HEALTH: PAHs can be pro-carcinogenic, carcinogenic or mutagenic having the potential to impact the immune and cardiovascular systems and hence pose a risk to human health (Lawal, 2017). Sixty percent of instances of lung cancer have been linked to mutations brought on by BaP and a few other PAHs (Bunton, 1996).
Based on occupational studies, (IARC 2006) determined that there is enough evidence to conclude that the following causes of lung cancer in humans: coal gasification, soot (found in chimney sweepers' occupational exposure), aluminum production, coal tar pitch (found in paving and roofing), iron and steel founding, and coke production (Straif, 2006). People's health is constantly at risk due to the ongoing production and emission of PAHs (Tiwari *et al.*, 2017).

CONCENTRATION OF POLYCYCLIC AROMATIC HYDROCARBON IN SOME AFRICAN CONTINENTS.

S/N	COUNTRY	SOURCES	CONCENTRATION (µg/kg)	CITATION
1	Ghana	Market smoked fish	406.39	(Palm *et al.*, 2011)
2	Egypt	Industrial discharge from polluted farm	28.80	(Hafez *et al.*, 2017)
3	Cote D’voire (Abidjan)	Smoked pork	122.31	(Manda *et al.*, 2012)
4	Uganda (Bobi market)	Smoked fish waste	58.10	(Ongwech *et al.*, 2013)
5	Nigeria (cities of Lagos & Ibadan) Port Harcout	Waste dumps Instant noodles	270 – 22247 564 ± 61 - 7889 ± 730	Adeyi & Oyeleke (2017) (Charles *et al.*, 2017).
6	Ethopia (Adis Ababa	Petroleum and biomass combustion	17 – 1640	(Prasse *et al.*, 2012)
7	Kenya	Agricultural soil contaminated through run off	2593 - 4356.15	(Mungai, 2018)
8	Tunisia	Petrogenic sources	120.01- 365.18	(Haddaoui *et al.*, 2015)
9	Tanzania	Soil contaminated at industrial area	104 - 35,890	Mahugija (2015)
10	South Africa	Industrial activities like iron and non-iron containing metal production, mining of coal, e.t.c	15,000	(Neuwoudt *et al.*, 2011)
11	Senegal	Pyrolytic sources	2 – 636	(Net *et al.*, 2015)
12	Morocco	Petrogenic sources with less concentration to combustion sources	21.6 – 108	(Guliana *et al.*, 2015)

MONITORING AND ASSESSMENT OF POLYCYCLIC AROMATIC HYDOCARBON

The methods that are most prevalent for extracting PAHs from an intricate sol matrix are the following: 2 phase hollow liquid phase microextraction (HF-LPME), silica cartridges, columns with gel beads, and straight immersion solid-phase microextraction (SPME) (Basheer and Ali, 2018). A number of techniques have also been developed for the identification of polycyclic aromatic hydrocarbons (PAHs), such as gas chromatography with flame ionisation detection (GC/FID) or gas chromatography with mass detection (GC/MS), and high-performance liquid chromatography (HPLC) fitted with fluorescence detector (FLD) and ultraviolet and fluorescence detection (UV/FL) (Ali *et al.,* 2019).

In laboratory studies, a number of biomarkers have demonstrated potential for aquatic organisms exposed to polycyclic aromatic hydrocarbons (PAHs), especially bivalves. Ruditapes philippinarum, one type of significant commercial bivalves that is was widely used as bio indicators in field monitoring (Pintado-Herrera *et al.,* 2020) and laboratory settings (Aouini *et al.,* 2018).

The toxic equivalency factor (TEF) method, a popular technique for determining the risk of PAHs, was utilized by both USEPA and WHO (1998). However, the job-exposure matrix (UEM) approach or data on industrial hygiene from a factory were utilized in recent epidemiological studies to directly assess occupational PAH exposure.

STRATEGIES THAT CAN BE USED TO PREVENT/ MITIGATE THE IMPACT OF POLYCYCLIC AROMATIC HYDROCARBON POLLUTION.

1. Spices, garlic, and onions are examples of ingredients with antioxidant qualities that can prevent PAHs from forming in fried pork (Da Paz *et al.,* 2017).
2. Alternative cooking techniques, such as cooking at lower temperatures, exposing the lean portion of the meat during grilling, avoiding direct flame contact when barbecuing, and using electric or gas broilers instead of charcoal, have been shown by to reduce the formation of PAHs in prepared foods (Bansal and Kim, 2015).
3. An important area of research that is currently developing to address contaminants like PAHs from different matrices, including soil, sediment, surface water, and groundwater, is nanoparticle (NP)-based eco-engineered bioremediation. As NPs evolve, they must be further improved, for example, by changing their surface features to create "functionalized nanoparticles," which can serve multiple purposes in the bioremediation industry (Basak *et al.,* 2020).

CONCLUSION

Anthropogenic sources categorized into household, mobile industrial and agricultural pollution are the main sources of Polycyclic Aromatic Hydrocarbons (PAHs). They are inhaled through air, eaten in food, contaminated soil, trophic transfer and maternal offloading. PAHs have diverse toxic effects on living organisms, including carcinogenic, mutagenic and teratogenicity properties. Exposures duration and dose influence the severity of the toxic effects. Effective monitoring, assessment and preventive measures are essential for managing PAH pollution and mitigating its adverse effects by deploying monitoring techniques, raising public awareness, implementing regulatory strategies, stakeholders can work towards reducing and safeguarding both environmental and human well-being.

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