

Organic Contaminants in Food: A Global Concern and a Measurement Challenge



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Key messages

- Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous, found in air, water and soil, and in the food we eat.
- Sufficient governmental support for metrology institutes is needed to enable laboratories and testing centres to monitor these ubiquitous food contaminants.
- Food safety regulations must keep up with the increasing availability and demand for food.
- A global approach should be taken to the production of certified reference materials for use in the analysis of foodborne PAHs.

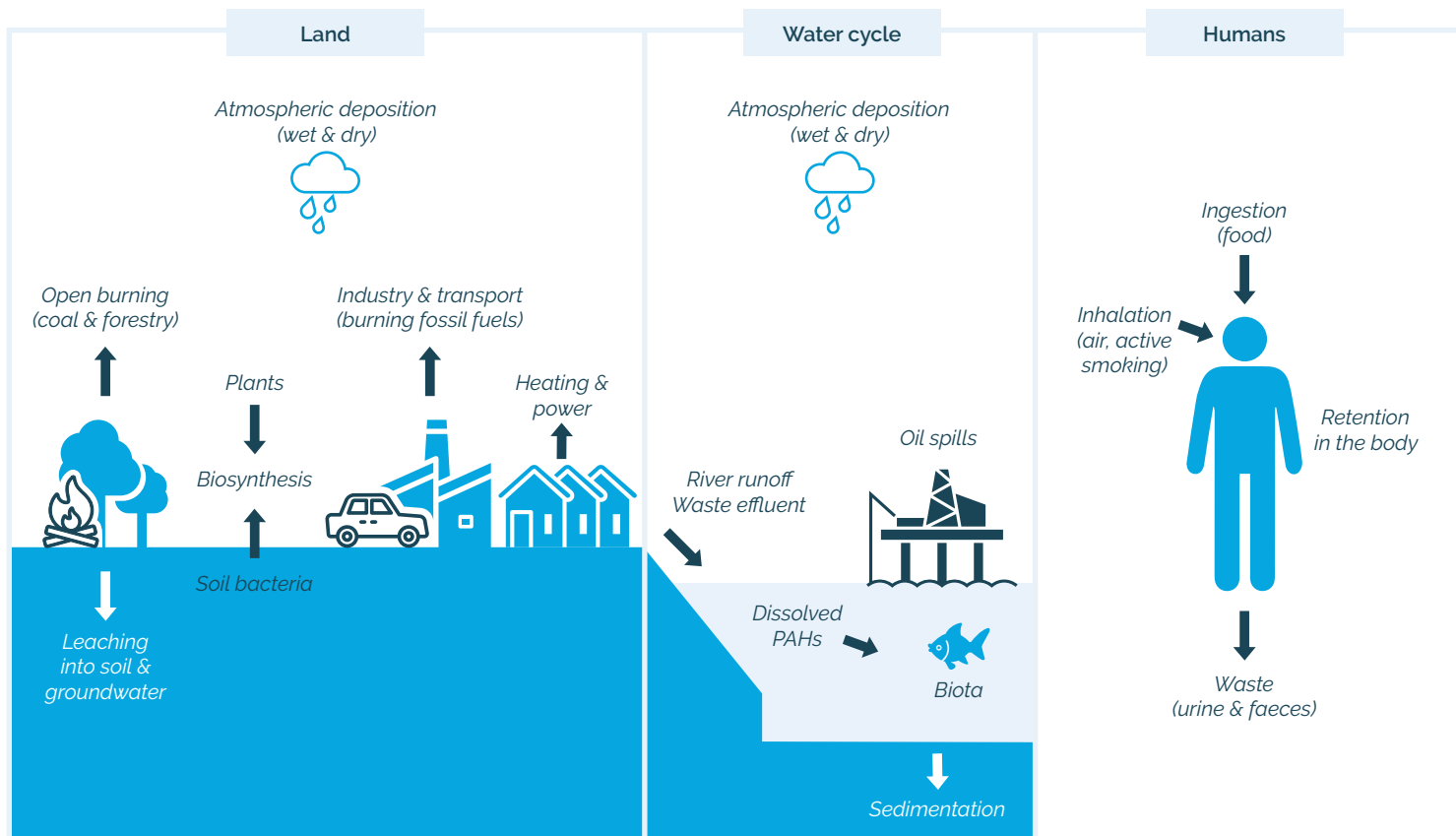
What's the issue?

Polycyclic aromatic hydrocarbons (PAHs) are a large and diverse group of organic chemical compounds present in all components of the natural environment; in air, water, soil, sediments, and biological organisms.¹ PAHs are formed whenever organic matter is burned. This can happen via natural processes, such as forest fires and volcanic eruptions, or via anthropogenic sources, such as the combustion of fossil fuels in industry and transport. In the home, PAHs are found in tobacco smoke, emissions from wood burning stoves and fireplaces. Food preparation processes such as barbecuing, smoking, drying, roasting, baking, frying, or grilling all greatly increase the occurrence of PAHs in food, but the main pathway by which PAHs enter the food chain is via absorption through the soil into crops.³ For non-smokers, up to 70% of a person's PAH exposure can be attributed to their diet.² PAHs present in the human environment are derived mainly from anthropogenic sources.

The widespread occurrence of PAHs has attracted significant attention due to their toxicity. Many PAHs are known to be hazardous to human and animal health and have been linked to various adverse effects including developmental abnormalities, DNA damage, alterations in enzyme activity, and reproductive impairments.⁴ PAH accumulation has been shown to cause pathological changes in human organs, such as the respiratory tract, kidney, and liver.⁵ The UN Environment Programme included PAHs as one of the primary issues in their 2020 Assessment Report on Issues of Concern.⁶

Certified reference materials play a vital role in validating analytical measurement methods, calibrating instruments, and checking the quality of products. Presently, the availability of food-matrix-based certified reference materials for PAHs is extremely limited, and the proficiency tests offered by metrology institutes cover only a narrow range of PAHs in some food products. This can lead to variation and high uncertainty in analytical results.^{7,20} Moreover, several countries have insufficient or no legislation to enforce acceptable levels of PAHs in foods.⁸

Although there is evidence that mixtures of PAHs are carcinogenic to humans based on inhalation and dermal exposure, data for humans ingesting PAHs via food remains scarce.⁹⁻¹¹ Therefore, action needs to be taken to enable effective, reliable, and accurate measurements in detecting foodborne PAHs. This will enable regulatory bodies to set clear regulations on PAHs in food products to protect consumers from potential health risks and help ensure food safety and quality in the region.



PAHs cycle in the environment. Adapted from: M. Derafshi, et al, *Acta hort regiotec*, 25, 2022(2): 174–180
DOI: 10.2478/ahr-2022-0021

Why is this important?

It has never been more expensive to access food in the Asia-Pacific region. According to the UN, between 2019 and 2020, Asia and the Pacific experienced a 4.5% increase in the cost of a healthy diet; the highest surge of anywhere in the world.¹⁰ As a result, nearly 1.9 billion people, or ~44.5 % of the region's population cannot afford a healthy diet.

Customers choose food for a variety of reasons. Cultural diversity and food availability are factors that influence an individual's diet, and their dietary patterns, preferences, and preparation techniques all vary. Several studies have already established a clear relationship between dietary patterns and daily intake of PAHs.¹⁹ This is why it is important to know where and how customers can access food with lower PAH levels.

The challenge for planners and national policymakers is to develop food regulations that prioritise healthy and safe food consumption. At the foundation of such an effort is the requirement for certified reference materials that can be used to check the quality and metrological traceability of products.

In terms of monitoring, Benzo(a)pyrene (BaP) is a PAH that is classified as carcinogenic to humans and it is generally assumed to represent PAHs as a whole. However, in a review of over 10,000 measurements of PAH levels in different food commodities, the European Food Safety Authority found that other PAHs were present in close to a third of all samples, where BaP was absent.²³ They concluded that BaP alone is not a suitable indicator for the occurrence of PAHs in food, suggesting instead that the sum of a series of PAHs would be a more effective measure of contamination. Therefore, improving the measurement capability for other PAHs, and combinations of PAHs, should be prioritised.

The role of metrology

Metrology, the science of measurement, plays a vital role in various aspects of human health and safety. Accurate measurement techniques for PAH levels in food commodities enable the assessment of potential exposure and risks to human health. Currently, the two main analytical techniques for determining PAHs in foods are high-performance liquid chromatography coupled to a fluorescence detector, and gas chromatography-mass spectrometry. These methods are sufficiently sensitive to determine PAH concentrations typically found in foods.¹²

Moreover, PAHs in a wide array of food categories need their maximum permissible levels to be identified.

This can only be accomplished if there are reference materials available for use. Reference materials are key tools used by analytical laboratories to check the quality of their results, and to ensure that their measurements are traceable to the International System of Units (SI).¹³

Reference materials – such as those used to determine food contamination – are produced by expert organisations such as the National Institute of Standards and Technology in the US, and the National Metrology Institute of Japan. They are then disseminated to regional measurement institutes and other labs to ensure consistency across all analytical measurements.

What should policy makers do?

PAH contamination is a global concern. Among the challenges to implementing metrological traceability are the availability of fit-for-purpose matrix-based reference materials. No single institute or economy has the resources to produce all of the required reference materials, so it is important to share a common understanding and global strategic vision around their development, and to enable relevant agencies in all economies to achieve successful PAH monitoring and assessment.

Government officials, policymakers and leaders from various sectors play an important role in contributing to scientific and technical research.

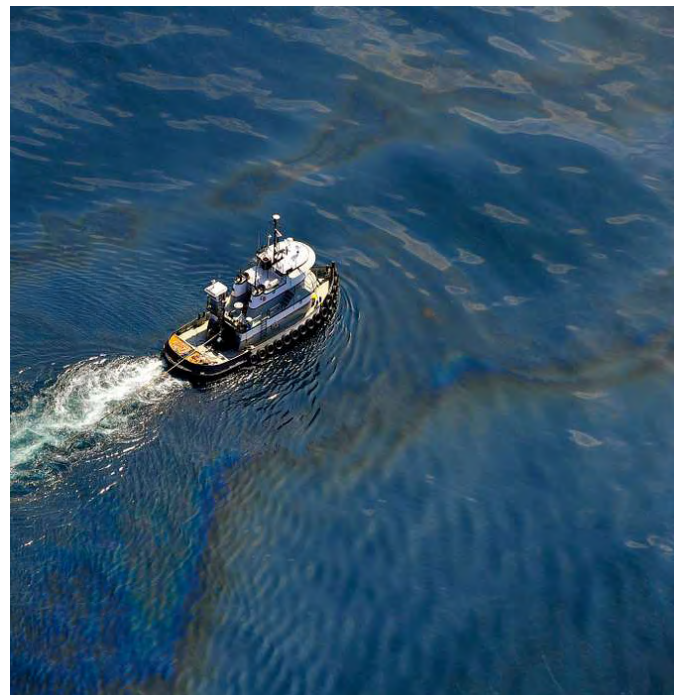
To address the current limitations in PAHs, we recommend:

1. Support technological advancements in analytical methods to develop faster, cheaper ways to detect PAHs;
2. Support the establishment of regulatory limits for PAH contaminants;
3. Promote and fund capacity building and harmonization of measurement procedures for PAHs;
4. Enable continuous monitoring and control of PAHs, including risk assessments related to the consumption of contaminated foods, and calculations to determine safe intake parameters;
5. Foster extensive research and development work in metrology to protect the health, safety and interests of every citizen.

Local example: Philippines

The Philippines is a developing country strategically located in Southeast Asia, surrounded by a vast maritime territory and known for its busy shipping routes.¹⁴ Throughout history, the Philippines has seen a number of devastating oil spills.¹⁵ A recent one was on February 28, 2023, when a motor tanker called MT Princess Empress carrying 900,000 litres of industrial fuel sank off Najuan, Oriental Mindoro. The oil spill caused extensive damage to the environment, estimated at around 7 billion pesos (US\$18 million).

As the country's oil spill monitoring agency, the Bureau of Fisheries and Aquatic Resources (BFAR) conducted analysis of samples from the area, measuring PAHs levels, including those of BaP. They detected low but elevated levels of PAHs in fish samples, and as a result, introduced temporary fishing bans in the affected areas. This affected the livelihood of more than 19,000 fisherfolk and their families.^{16, 17, 18} In times like these, real-time, accurate and precise measurements of PAHs in aquatic species is crucial for ensuring livelihoods, food safety, and the health of citizens. Proper monitoring helps regulatory bodies to identify and enforce regulations in areas that may pose public health risks.



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