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Relevance of Characterizing PAHs on PM in South-Central Chilean Cities

Fabián Guerrero*

Department of Mechanical Engineering, Universidad Técnica Federico Santa María, Chile

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***Corresponding author:** Fabián Guerrero, Department of Mechanical Engineering, Universidad Técnica Federico Santa María, Avenida España 1680, Valparaíso 2390123, Chile

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Opinion

South-central Chilean cities, such as Rancagua, Talca, Curicó, Linares, Los Angeles, Concepción, Temuco, Osorno, Valdivia, and Coyhaique, primarily stand out as cities with high levels of atmospheric pollution. The residential wood combustion (RWC) is the major contributor to this phenomenon, turning these zones into saturation areas due to high concentrations of particulate matter (PM_{10}, and $PM_{2.5}$) [1,2].

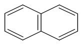
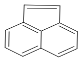
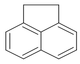
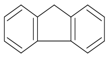
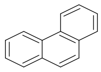
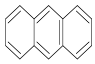
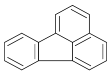
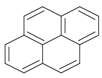
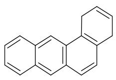
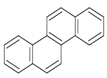
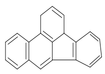
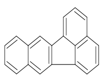
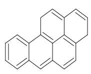
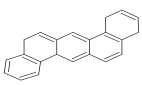
RWC generates a variety of pollutants, such as particulate matter (PM_{10}, $PM_{2.5}$, and $PM_{1.0}$), atmospheric organic aerosols, gaseous combustion products, inorganic compounds, and polycyclic aromatic hydrocarbons (PAHs), the latter being chemical compounds of considerable concern to the scientific community given the carcinogenic and mutagenic properties of some of these substances and their derivatives. In fact, due to their carcinogenic activity, 16 PAHs have been listed as priority PAHs by the Environmental Protection Agency (EPA-USA), as shown in Table 1, naphthalene (the lightest of the PAHs) and benzo(a) pyrene being the most toxic and carcinogenic, respectively [3,4].

Most investigations into air quality in Chile are focused on characterizing emissions of particulate matter (PM_{10} and $PM_{2.5}$); nevertheless, it is essential to conduct organic speciation of PM to identify its chemical composition, with particular attention paid to PAHs given their toxicity as carcinogenic and mutagenic compounds. As airborne PAHs can adsorb on $PM_{2.5}$, the responsibility for particle toxicity may be attributed to these chemical compounds. Most polycyclic aromatic hydrocarbons (70 to 90%) are adsorbed on surfaces of particles with a micrometer-scale diameter (inhalable particles) [5]. These particles can settle in the respiratory system and thus increase the occurrence of adverse health conditions. Since PAHs are semi-volatile compounds, the species with the highest molecular mass predominates in the chemical speciation of $PM_{2.5}$, and this mass fraction is highly harmful to humans. Therefore, exposure to PAHs may increase the risk of skin and lung cancer, among other diseases [5].

In Chile, it is estimated that an increase in emissions of PAHs in the particulate phase will be produced because of increasing residential wood combustion in south-central cities of the country due to confinement brought by the current sanitary emergency (COVID19 pandemic). As the population is required to stay indoors for a significant fraction of the day, it is expected that the hours of operation of household stoves will increase, and, thus, an increase in PM emissions to the atmosphere is also projected. Moreover, another interesting source of PAH emissions that must be considered is the occurrence of forest fires, where this contribution may be intensified as a result of the recent recorded increase in the number of these events and burnt area, partially explained by climatic factors, such as the increase regarding extreme temperatures and the occurrence of heat waves combined with the reduction in the level of precipitations, which leads to drought conditions, enhancing a predisposition of vegetation to inflammation [6].

In this scenario, it is urgent to study PAHs in greater depth in densely polluted Chilean cities, such as Coyhaique, which has the highest concentrations of fine PM (annual average of 66 μg m^{-3}) in the Americas [7]. Furthermore, this characterization should address the concentration of these substances as well as their spatial distribution, spatial variation, source distribution, and risk management for human health. This information would provide a scientific basis for the establishment or improvement of standards to further restrict the emissions of these pollutants to reduce impacts on human health.

Table 1: Selected properties of US EPA 16 priority PAHs.

Priority PAHs	Structures of PAHs	Ring Number	Molecular Weight (gmol^{-1})	Boiling Point (°C)	Vapor Pressure (mmHg at 25°C)	Aqueous Solubility (mg L^{-1} at 25°C)
Naphthalene (*)	 $C_{10}H_8$	2	128.0626	218	1.8x10^{-2}	32
Acenaphthylene (D)	 $C_{12}H_8$	3	152.0626	265	2.9x10^{-2}	3.9
Acenaphthene	 C_{12}H10	3	154.212	278	1.6x10^{-3}	3.9
Fluorene (D)	 C_{13}H10	3	166.223	295	7.1x10^{-4}	1.9
Phenanthrene (D)	 $C_{14}H_{10}$	3	178.0783	339	9.6x10^{-4}	1.1
Anthracene (D)	 $C_{14}H_{10}$	3	178.0783	340	1.7x10^{-5}	0.05
Fluoranthene (D)	 $C_{16}H_{10}$	4	202.0783	375	5.0x10^{-6}	0.26
Pyrene (D)	 $C_{16}H_{10}$	4	202.0783	360	2.5x10^{-6}	0.13
Benzo(a)anthracene (B2)	 $C_{18}H_{12}$	4	228.0939	435	2.2x10^{-8}	9.0x10^{-3}
Chrysene (B2)	 $C_{18}H_{12}$	4	228.0939	448	6.3x10^{-9}	2.0x10^{-3}
Benzo(b)fluoranthene (B2)	 $C_{20}H_{12}$	5	252.0939	481	5.0x10^{-7}	1.4x10^{-3}
Benzo(k)fluoranthene	 $C_{20}H_{12}$	5	252.0939	481	5.1x10^{-7}	7.0x10^{-4}
Benzo(a)pyrene (B2)	 $C_{20}H_{12}$	5	252.0939	495	5.6x10^{-9}	3.0x10^{-3}
Dibenzo(a,h)anthracene (B2)	 $C_{22}H_{14}$	5	278.1096	524	2.0x10^{-11}	5.0x10^{-4}

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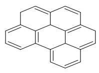
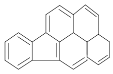
Benzo(g,h,i)perylene (D)	 $C_{22}H_{12}$	6	276.0939	500	$1.0x10^{-10}$	$2.6x10^{-4}$
Indeno(1,2,3-c,d) pyrene (B2)	 $C_{22}H_{12}$	6	276.0939	536	$1.4x10^{-10}$	$1.9x10^{-4}$

*Not included in priority list; D, not listed regarding human carcinogenicity; B2, probable human carcinogen [3].

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