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Monitoring air quality in Cyprus (2016-2022)

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Abstract Air pollution is a significant environmental threat to public health worldwide. In Cyprus, the laboratory of Environmental Chemistry and Control of Effluents of the State General Laboratory in collaboration with the competent Authorities, the Department of Inspection of the Ministry of labour, develops and implements programs for monitoring every year the efficiency of the quality of air, using special filters. Heavy metals (As, Cd, Ni, Hg, Pb), other metals (Al, Fe, Cu, Zn, Mn, Cr, V), ions (Cl^-, $SO4^{2-}$, NO_3^-, Na^+, K^+, NH_4^+) as well as **8** Polycyclic Aromatic Hydrocarbons (PAH's) including benzo(a)pyrene, were monitored and controlled systematically and effectively for more than a decade.
Instrumental techniques like ion chromatography, ICP, ICP-MS and HPLC-fluorescence are used to determine ions, metals, and PAH,'s respectively. In this study, the results of these parameters are presented for the years 2016–2022. Heavy metals, ions, and PAHs are found in low concentrations ranging from low nanograms to micrograms per m^3.

Keywords: *air quality, monitoring, polycyclic aromatic hydrocarbons, heavy metals, ions*

1. Introduction

Air pollution occurs when harmful or excessive quantities of substances including gases, particulates, and biological molecules are introduced into Earth's atmosphere. It may cause diseases, allergies and even death to humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Both human activity and natural processes can generate air pollution.

During 2016-2022, the laboratory of Environmental Chemistry and Control of Effluents (State General Laboratory) in collaboration with the competent Authorities (The Department of Inspection of the Ministry of labour) continued monitoring the air quality at various locations all over Cyprus (Figure 1). The monitoring was carried out via the operation of stations fully equipped with special filters that absorbed specific amount of air .

Figure1: Distribution of Atmospheric Air Quality Monitoring Sampling Stations in Cyprus (Traffic Stations – red colour, Residential Stations – green colour, Industrial Stations – yellow colour and Background Stations- blue colour) [2] .

2. Materials and Methods

2.1. The Instrumental techniques ,Ion Chromatography, ICP, ICP-MS and HPLC-fluorescence were used to determine ions, metals and PAH 's respectively. In this study, the results of these parameters for the years 2016–2022 are presented .

Sampling was carried out at the various sampling locations ,urban and rural , using high volume air pumps and Quartz filters. Specific volume of air was sampled for 24 hours a day of each year: for PAHs 233m^3 air /24h using filters with diameter of 44 mm , for ions 28,3 m^3 air /24h using filters with diameter of 20mm and for metals 25.44 m^3 air /24h using filters with diameter of 18mm.

PAHs were extracted from the filtered particulate matter using organic solvent extraction and analyzed using HPLC-fluorescence.

Metals (As, Cd, Ni, Hg, Pb, Al, Fe, Cu, Zn, Mn, Cr, V) were determined after microwave digestion using Inductively Coupled Plasma. Hg was determined after digestion with a mixture of sulfuric acid, nitric acid, permanganate and potassium persulfate by a cold-vapour atomic absorption spectrometry.

Ions were determined, after water extraction, using Ion Chromatography.

3. Results and DISCUSSION

There are various anthropogenic emission sources for PAHs: Domestic, Mobile, Industrial, and Agricultural. PAH can also be formed naturally as a result of uncontrolled or accidental burning. Several member states use BaP as a marker for carcinogenic PAH for air quality management purposes. BaP has been shown to make a consistent contribution to the total carcinogenic activity of predominantly particle-bound PAH based on measured annual average concentrations at a wide range of European sites [1].

*The results of this study show that **PAHs concentrations** are in general very low in all sampling locations . (Figure 1,2). Higher concentrations are found in urban areas, with peak concentrations measured at urban residential sites with increased traffic (Limassol), **Table1 and Figure 1.** Total PAH's were determined at concentrations lower than 0.843 ng m^{-3} for the last 4 years ,only those in Limassol residential area were found to be higher as 1.292 ng m^{-3} for the year 2022. (Table1).A significant reduce is noted though for the years 2019-2021.*

Table 1. Average Concentration of total PAHs in Limassol/Cyprus (ng/m^3)

ng/m3 Limassol	2019	2020	2021	2022
Average-Benzo(a)pyrene	0.049	0.109	0.025	0.159
Average-TotalPAHs	0.573	0.957	0.273	1.292

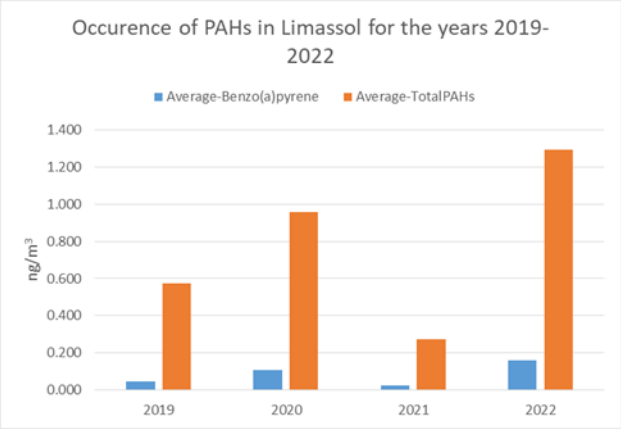

***Figure 1:** PAHs occurrence in Limassol of Cyprus for the years 2019-2021.*

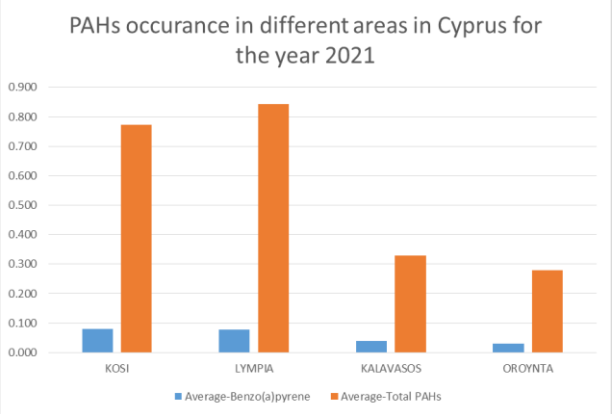

***Figure 2:** PAHs occurrence in different areas in Cyprus for the year 2021*

The max, min and average concentration values of anions **Cl^-, NO_3^-** and **$SO4^{-2}$** in air are shown in Figure 3 and the max, min and average concentration values of cations, **NH^{4-}**, **Ca^{2+}**,**K^+**, **Mg^{2+}**, **Na^+**, are shown in Figure 4.

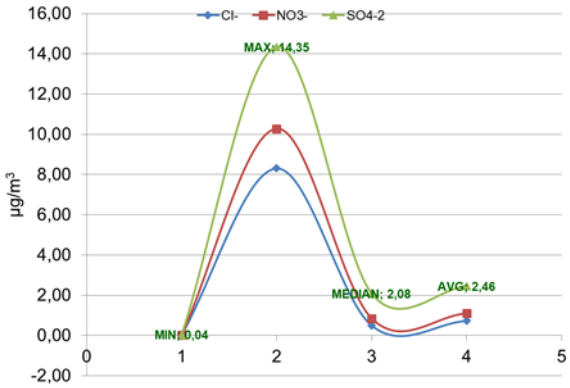

***Figure 3**. Concentration of anions in all sampling locations in Cyprus during 2016-2018.*

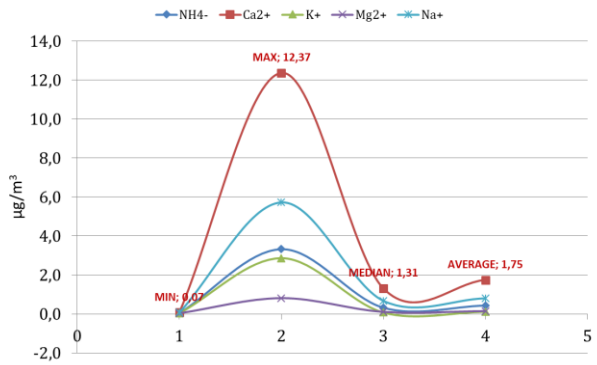

Figure 4. Concentration of cations in all sampling locations in Cyprus during 2016-2018.

The max, min and average concentration values of anions **Cl^-, NO_3^-** and **$SO4^{-2}$** in air are shown in Figure 3, and the max, min and average concentration values of cations, **NH^{4-}**, **Ca^{2+}**,**K^+**, **Mg^{2+}**, **Na^+**, are shown in Figure 4

Concentrations of arsenic (As), cadmium (Cd), lead (Pb) and nickel (Ni) in the air are generally low in Europe, with few exceedances of the environmental standards[1]. Despise their low concentration existence they contribute to the deposition and accumulation of toxic metal levels in soils, sediments and organisms.

Heavy metals were determined at low concentrations, close to **LOQ** ,which is 0,0008 µg m^{-3} for **Cd,** 0,003 µg m^3 for **Co**, 0,012 µg m^{-3} for **Pb** and **Cr** and 0.008 µg m^{-3} for **As**, 0.067 µg m^{-3} for **Cu**, 0,024 µg m^{-3} for **V**, 0,4 µg m^3 for **Hg,** 0,012 µg m^{-3} for **Ni** and 0,2 µg m^{-3} for **Al**, Table 2-3.

Table 2-3. *Maximum, Median and average concentrations (μg/m^3) of metals measured between 2016-2018 in Cyprus*

μg /m3	V	Co	Al	Fe	Cu	Cr
MAX	0.026	<LOQ	7,63	1,855	0.069	0.0193
Median	<LOQ	<LOQ	<LOQ	0,193	<LOQ	<LOQ
AVG	0,024	<LOQ	0,53	0,079	0,067	0,012

μg /m3	Ni	As	Cd	Hg	Pb
MAX	0,241	<LOQ	0.0031	0,012*10-4	0,022
Median	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
AVG	0,012	<LOQ	5.39*10-5	0,0004	0,012

4. Conclusions

Heavy metals, Ions, and PAHs are generally found at low concentrations an indication of low or no air pollution.

Several member States use BaP as a marker for carcinogenic PAH for air quality management purposes. BaP has been shown to make a consistent contribution to the total carcinogenic activity of predominantly particle-bound PAH based on measured annual average concentrations at a wide range of European sites. In Cyprus the measured levels for BaP are below the target value for BaP for the protection of human health which is 1 ng/m^3 [3] for a calendar year compare to other member states who have measured concentrations above the limit [1]. These values are most predominant in central and eastern Europe.

Toxic metal pollutants can have harmful effects on plants animals and humans. Although the atmospheric concentrations of As, Cd, Pb and Ni may be low in Cyprus, they still contribute to the deposition and build up of toxic metals in soils, sediments and organisms. These toxic metals do not break down in the environment and some bioaccumulate and biomagnify, so their further monitoring is an essential need.

Anions and Cations are monitored for the source identification of air particulate matter and the estimation of the contribution of the dust transported from the Sahara Desert and other North Africa and West Asia areas to the high levels of air particulate matter determined .

5. References

1. European Environment Agency, Air Quality in Europe – 2018 report, No 12/2018.
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3. The 2008 Ambient Air Quality Directive (2008/50/EC).