Article

Low-Cost Passive System for Environmental Monitoring

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Abstract: The present work aimed to validate a low-cost passive monitoring procedure. For its validation, the monitoring of atmospheric organic pollutants - polycyclic aromatic hydrocarbons (PAH) was carried out in a capital of the central-western region of Brazil. The sensors were fixed on poles intended for electrification during the dry season. After 15 days, samples were extracted by solvent extraction and analysed by High-Resolution Gas Chromatography with Flame Ionization Detector (HRGC-FID). For the validation of the procedure, PAHs monitored and standardised by the American Environmental Agency (EPA), a benchmark for environmental monitoring of air quality by several countries, were analysed. The results demonstrated that the low-cost passive monitoring method was effective in the quantification of PAH in the environment-air, capable of being used by countries that do not have many resources for monitoring air quality.

Keywords: low-cost monitoring; environment, air-pollution

1. Introduction

Air pollution is composed of a complex mixture of solid particles and droplets dispersed in the air atmosphere, formed by a diffuse multifactorial set [1].

The large volume of internal combustion engines and industrial processes emitting particulates in the atmosphere containing CO, Pb and other trace elements, NO2, SO2 and other substances grouped in complex particulates together with incomplete reactions of the primary pollutants are responsible by the more significant amount of particulates that pollute the atmosphere and the air that living beings breathe for their maintenance [2,3].

Countries with atmospheric air monitoring systems only regulate emissions of SO_x, NO_x, CO, Pb and O_3, except the USA, which limits the discharge of pollutants from the atmosphere by segregating them into two different standards - PM, less than 2,5µm (PM2,5), capable of causing diverse pathologies in the beings that depend on the respiration for its maintenance; and inhalable coarse particles with diameters of less than 10µm (PM10), which affect the quality of the artificial environment, causing fogs and damage to buildings and monuments [3-5].

However, there are no norms governing air quality that relativise the size of particulate matter dispersed in the atmosphere and the effects on public health and the individual well-being of human beings.

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The only way to monitoring atmospheric air quality is through the use of EPA standardization as a source of technical and scientific reference and the scientific work of research centres and universities concerned with atmospheric air quality and its implications for the human health [6,7,2,8,9,10].

The projections for atmospheric pollution are that there is an exponential increase in the coming years, so it is important to monitor air quality, even in countries that do not allocate resources for emission control, either due to lack of financial resources, or lack of political interest, remembering that emissions do not encounter political barriers, affecting the globe in a diffuse way.

The current economic polarization towards the East, with targets for growing industrialized production in China and India, with the opening of those markets, is alarming for the conditions of survival on the Planet, since it has already been widely found that the most significant source of air pollution [11], which is obtained in these countries, mainly by the burning of coal.

In China, poor air quality meant that during the 2008 Beijing Olympics, the government took steps to reduce air pollution, restrict vehicle traffic, and ban the operation of some industries.

Concerned about air quality, most countries monitoring air pollution, especially in large capitals.

However, monitoring is generally done to monitor the levels of particulates and substances most commonly encountered in the urban air-environment, which are substances derived from the emission of organic compounds from the incomplete combustion of hydrocarbons from the incomplete combustion of vehicle engines.

Aromatic hydrocarbons, notably benzene, toluene, ethylbenzene and xylenes (BTEX), are present in urban areas as significant pollutants with most of the urban air pollution by BTEX, pollution. Benzene is the primary organic pollutant found in the air where fossil fuels are emitted and subject to restrictions in several countries.

The European Union, for example, introduced Directive 2000/60/EC [12], which set the benzene emission limit for the urban atmosphere at a concentration of 5 $\mu g.m^{-3}$.

Together with the monitoring of BTEX the control of the levels of monoxide and carbon dioxide, which are the passive substances of control and standardization by the cities that represent the great urban centers of the world, and that evaluate from the aspirated air, happening [13], to the way in which the vehicle parking angle can mitigate the effects of air pollution on humans [14].

The monitoring that is carried out by the governments of the big cities is an expensive process, since it depends on fixed and large equipment and that, therefore, has to be spread by several points of the big cities to obtain statistical data capable of predicting and controlling levels of environmental pollution throughout the vast urban center. Besides, active and fixed monitors are subject to external punctual influences that can mask the results of atmospheric air quality data through this type of monitoring.

Mobile aspirated equipment which is fixed in public vehicles which travel in different urban areas and on highways are subject to being carried of substances emitted by an individual vehicle that, perhaps, is in front of aspirated pickup and that is emitting pollutants by its discharge pipe, in disagreement with the acceptable and acceptable standards for the human life and the guarantee of quality of the environment.

Fixed sensors also suffer the influence of deregulated vehicles passing close to or standing in front of the fixed vacuum cleaner, and which, when leaving the site, emit large amounts of smoke and particulates, altering the statistical reliability of the results, mainly due to the fact of these are generally collected in short periods of up to 24 hours.

The reading of the results obtained by the sensors installed in large urban centres treated statistically. However, vehicles outside the usual emission standards, cause significant changes in the statistical curves, becoming accurate data capable of changing the mean.

Another important factor that stands out against the active monitoring system is its high cost, which makes it difficult to install in small urban centers and rural areas, and which prevents them from being installed in residences, places that have been studied, such as synergistic point between air pollution and diseases that affect human health [15].

To improve the air pollution monitoring system, to make it cheaper, accessible to all air pollution control sites, some surveys have been carried out to improve the use of plants and animals [16-18].

An interesting study was carried out in Bahia, Brazil, to control the level of atmospheric pollution through passive monitoring, specifically biomonitoring through plants, to determine the effects of genotoxic agents [17]. The plants can be used as bioindicators since they grow over time, is, therefore, able to register biodynamically the changes of the atmospheric air, due to which they suffer from the variations of the quality of the air, being able to demonstrate clearly and repeatedly the harmful effects of the atmospheric pollution on living organisms.

The authors used T-pallida clones, plants commonly found in urban public parks, and placed them at 1.70m from the ground to perform passive biomonitoring at locations of variable flows of vehicles, during the interregnum of approximately one and a half years , with positive results for genetic alteration due to the anthropogenic action generating atmospheric pollution [17].

In an urban centre in Italy, passive sensors already found on the commercial level, from Radiello®, were used to monitor and control vehicular pollution [18]. These sensors have long used in atmospheric air monitoring surveys, based on the adsorption of particulates in a polyurethane foam, which can be exposed, and in closed environments such as residences and work environments [19,20]. The foam, called PUF, may be encased in a stainless steel chamber with openings inside windows for attachment to outdoor environments [21,22].

Biomonitoring of air pollution can also be done by analysing the fur and downs of wild animals and birds [23,24].

Brait [19] analyzed the levels of metals found in wild animals and pigeons which, because they are birds that adapt very well to living in cities, are endogenous due to food; and exogenous through substances that are present in the atmospheric air and that drink in their feathers due to the great oiliness that constitutes a protection of natural impermeability in birds [19].

As animal biomonitoring presents many difficulties in its use, from legal problems to the difficulty of collecting hairs from wild animals and capture for feather collection for the pigeons that inhabit the great centers, as well as acceptance of the results, given the controversy of the This process involves several phases and washing procedures for the preparation of samples [19,23].

Brait [19] developed a passive monitoring system, called SISCO - Atmospheric Pollutant Collection System.

For the development of SISCO, Brait [19,23] attempted to reproduce the sorption that occurs in poultry wax by the deposition of a water-insoluble polymethylene wax in quantitative filter papers placed in the molten wax.

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The wax used was chosen to reproduce more accurately the one found in pigeon feathers, because the aim of the work was the passive monitoring of urban atmospheric air, without the use of biomonitoring.

The filter papers prepared with the wax, fixed on aluminium support at 29 points located in high traffic areas of the city of Goiânia (Goiás), located in the Center-West Region of Brazil.

Passive sensors, SISCO, were placed on electricity poles intended for public lighting, at the height of approximately 4,5m, to avoid handling by curious pedestrians exposed during the regional dry season for 15 days.

Brait [23] evaluated trace elements in several locations in the urban region of Goiânia, through the use of the passive system called SISCO. Such monitoring showed the presence of total particulates and trace elements such as Cd, Cr, Pb, Cu, Fe, Mn, Zn, all deleterious to human health and constituents of air pollution, due to anthropogenic action.

Thus, Brait [23] affirmed that the low cost and the great ease of handling with this type of passive monitoring of the environment-air control, allows the monitoring of atmospheric pollution levels by trace metals, with higher efficiency and lower cost than that done by biomonitoring with animal hairs and feathers, because the restrictions arising from the difficulties of collecting the hairs and feathers of the animals eliminated, as well as the variable of their location, since the fixed points in predetermined places of the centers urban, provide the precise monitoring of air pollution, in the places where it is desired to control.

Air pollution is not limited to assessing the presence of BTEX and trace elements. Organic substances, such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and polycyclic aromatic hydrocarbons (PAHs), often resulting from applications of pesticides in the countryside, which are carried by the wind, reach the urban area, contaminating the air [25,18,26].

The same is true of PAHs from incomplete burning of fossil fuels and manufacturing processes occurring in industrial areas, and especially from internal combustion engines, which can be monitored through passive sensing, with good results, combined with simplicity and the low cost of the procedure [22,21].

The present work aimed to validate the passive monitoring by the use of passive, low-cost sensors for application in drought periods and closed environments, using the reference to the qualification of PAH present in atmospheric air.

2. Materials and Methods

The SISCO system, developed by Brait and Antoniosi [23], consists of a rod attached to an aluminium circle, fixed with a filter paper embedded in wax.

The SISCO system was adapted to minimise the costs of the passive sensing system, by replacing the aluminium circles with embroidery racks commonly found in the market for wood products with diameters of 20 and 30 cm.

The racks were rinsed with water and detergent, rinsed with running water and then rinsed with distilled and deionised water and sprinkled with Absolv Tedia® grade acetone, and finally arranged for drying.

The fixing of the adsorbent elements was carried out in a clean environment, by directly affixing the filter paper elements 20 cm in diameter, and polyethylene disks with diameters of 30 cm, in the frames, which, being composed of two concentric circles of wood, provide the fixation of the paper and the polyethylene, without any difficulty, as shown in Figure 1.

Figure 1. Passive monitoring system mounted with a 0.25-inch aluminium bar and two frames for embroidery in wood, where adsorbent elements were fixed, mounted on a power pole.

The frames were attached to the aluminum rods, both previously brushed, with the help of steel wool, to remove any traces of oil and other substances used during the manufacturing process; washed with acetone; and subsequently rinsed with distilled water and deionized water, sprinkled with Absolv Tedia® acetone and dried to room temperature.

After assembly, the passive air pollution monitoring systems, the SISCOs, were packed in polyethylene bags and sealed. The choice of polyethylene as a shell for SISCOs based on the lack of substances in this polymer that could interfere with the research of atmospheric pollutants, the focus of the research.

The SISCOs were fixed at the height of 4,5m from the ground, on poles intended for public lighting, so that there was no possibility of handling by people, and only after their fixation was that the casings were removed, thus avoiding any contact with substances that could alter the results of the research, such as oils and fats or other substances that may arise from the handling or the setting environment of the sensors.

SISCOs were set at 29 points in the city of Goiânia, during the 15-day, after the 100-day drought period in the city, aiming to collect the highest index of particulates and substances dispersed in the urban atmosphere.

The choice of points was made in a way that allows the monitoring of areas of large traffic flows and the incidence of transformation industries, which eliminate waste in the environment-air.

In addition, SISCO was installed in green belt regions, such as parks and Zoological Gardens, a major highway for interstate access to the capital of Goiás, and regions close to cities and with predominant rural activity in their economies, to verify the the possibility of collecting particulates from fires and monitoring the presence of toxic organic substances arising from vehicles and production zones throughout the urban perimeter of the city of Goiânia, chosen to carry out the research.

The location of the SISCO in the city of Goiânia, as well as the spatial representation of the city in the Brazilian territory, is represented in Figure 2.

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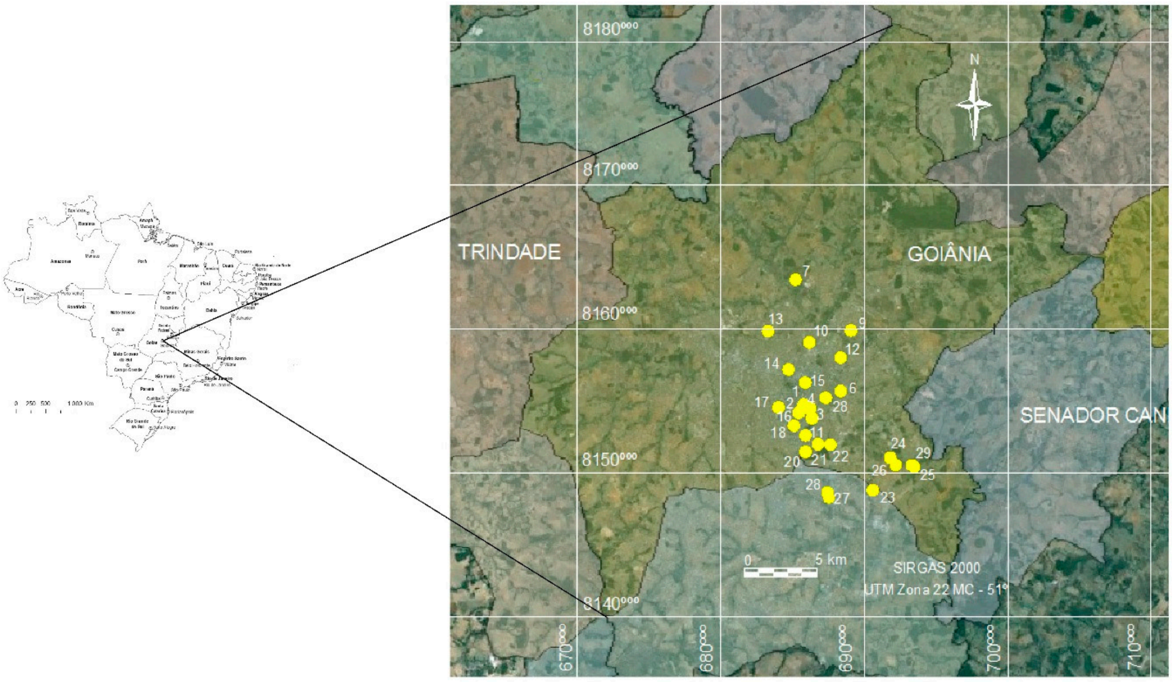

Figure 2. Location of SISCO distributed in the city of Goiânia (GO, Brazil).

The location-specific data of the SISCO, with coordinates for positioning by latitude and longitude, as well as the referencing of the sectors that were monitored, are described in Table 1.

Table 1. Locations of SISCO passive monitoring sensors, containing UTM coordinates and positioning by latitude, longitude and altitude

#	Name of the streets of SISCO instalation	X (UTM)	Y (UTM)	Latitude	Longitude
1	Praça Cívica 01 c/Rua 16	687954	8115979	16º40'50''S	49º15'32''O
2	Praça Cívica , n.º 565	685819	8154776	16º40'56''S	49º15'35''O
3	Rua 82, esquina c/ Rua 10	686147	8155000	16º40'49''S	49º15'16''O
4	Rua 96 c/Rua 97	686134	8154716	16º40'60''S	49º15'20''O
5	Campus I UFG	687242	8155406	16º40'42''S	49º14'54''O
6	Praça da Bíblia	688282	8155870	16º40'18''S	49º14'05''O
7	Campus II UFG [1]	685182	8163659	16º36'08''S	49º15'51''O
8	Perimetral Norte I	8684200	8160564	16º37'57''S	49º15'14''O
9	Aeroporto Santa Genoveva	689045	8160102	16º38'01''S	49º13'45''O

10	Setor Criméia Leste	686083	8159308	16º38'20"S	49º15'22"O
11	Praça do Cruzeiro	686268	8154006	16º41'22"S	49º15'12"O
12	Setor Jaó	688275	8158235	16º39'01"S	49º14'03"O
13	Av. Perimetral Norte II	683192	8160114	16º38'02"S	49º16'54"O
14	FAMA	684606	8157424	16º39'31"S	49º15'12"O
15	Setor Aeroporto	684463	8156514	16º40'00"S	49º16'13"O
16	Setor Oeste,	685337	8154391	16º41'08"S	49º15'43"O
17	Setor Oeste – Zoológico	683913	8154767	16º40'58"S	49º16'31"O
18	Setor Marista	684988	8153500	16º41'37"S	49º15'55"O
19	CENG	685783	8152826	16º41'58"S	49º15'28"O
20	Parque Areião	685781	8151661	16º42'36"S	49º15'27"O
21	Setor Pedro Ludovico	686687	8152171	16º42'23"S	49º14'39"O
22	Jardim Goiás	687525	8152162	16º42'17"S	49º14'26"O
23	Parque Atheneu	690485	8148955	16º44'15"S	49º12'40"O
24	Alphaville	691722	8151197	16º42'51"S	49º12'04"O
25	Portal do Sol II – no lixão	693239	8150663	16º43'08"S	49º11'14"O
26	Portal do Sol I	692111	8150702	16º43'08"S	49º11'14"O
27	BR-153 (I)	687522	8148258	16º44'28"S	49º14'34"O
28	BR-153 (II)	687304	8148837	16º44'11"S	49º14'35"O
29	Jardins	693259	8150657	16º44'02"S	49º12'35"O

[1] Campus of Federal University of Goiás

3. Results

After 15 days, the sensors were removed from the environment and re-wrapped in polyethylene wrappings and sealed to the laboratory for PAH analysis.

Of the 29 sensors that were fixed, five were discarded due to the presence of bird waste or by breaking the adsorbent elements.

The elements constituted by polyethylene were quickly released from the frames, due to their low coefficient of friction with the wood, and were discarded for the analyses carried out to qualify PAH, in the environment-air.

The SISCO was disassembled, the frames were removed, and with the fixed paper in the concentric rings of the frames, rectangular samples with 2.5 cm were taken from the central region of the filter papers, using two sterile scalpel blades arranged on the side to side.

The samples were packed in test tubes and weighed on an Ohaus brand, model AS 120, with an accuracy of 0.1 mg.

2 mL of 10% v/v solvent of diethyl ether in hexane was added, the samples after compacting with a glass rod, to be wholly immersed in the solvent.

The samples were centrifuged in orbital shaking for 12 hours, for the extraction of all the adsorbed particles by the filter paper, with the solvent affixed in 2 mL bottles and kept in a freezer at about -12°C, so that there was no deterioration of the samples [27]. GC-MS mass spectrometry [27] was used to determinate the most common PAH.

A gas chromatograph GC-17A-Shimadzu, coupled to a Shimadzu QP5050 mass spectrometer, was used to identify the PAHs in the samples. The injection conditions were also performed according to the EPA TO-13A [27], with an injector at 300°C in the splitless system, with an injection of 2 μL of sample. The initial oven temperature was 50°C, with an initial waiting time of 4.0 min and heating ramp of 10° C min^{-1} to 300°C and final wait time of 10 min. The entrainment gas was helium with a linear velocity of 29.2.

Table 2. List of PAHs analysed.

#	PAH	#	PAH
1	**Naftaleno**	**9**	**criseno**
2	**Acenafteno**	**10**	**Benzo(b)fluoranteno**
3	**Fluoreno**	**11**	**Benzo(k)fluoranteno**
4	**Antraceno**	**12**	**Benzo(a)pireno**
5	**Fenantreno**	**13**	**Benzo(e)pireno**
6	**Fluoranteno**	**14**	**Benzo(g,h,i)perileno**
7	**Pireno**	**15**	**Indeno(1,2,3,cd)pireno**
8	**Benz(a)antraceno**	**16**	**Dibenz(a,h)antraceno**[1]

[1] 16 EPA PAH.

For the determination of PAH in the analysed substances, the constant elution time was observed in the EPA TO-13 standard [27], since the chromatographic conditions used in this work followed that standard, with the blank extraction, constant of Figure 3.

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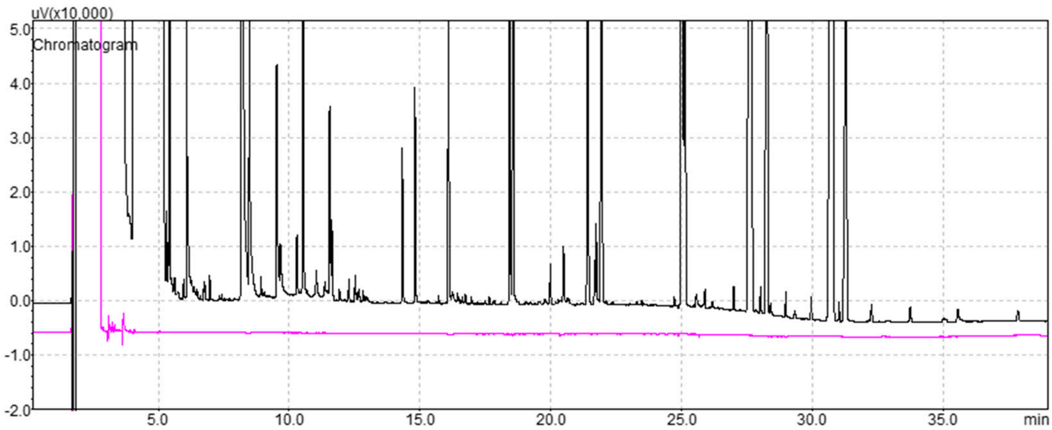

Figure 3. Chromatogram with blank extraction.

4. Discussion

The mass spectrometry analysis, although very efficient for the determination of organic compounds in several types of matrices, did not show good results for the analyzes of the samples of the air pollutants that it was intended to analyze, since the noise level of the mass spectrometer presented very close to the PAH peaks, probably due to the fact that they are traces of pollutants, having been abandoned.

Analysis by GC-FID was made, since the noise level produced by this method of analysis was shallow, allowing better identification of traces of substances, such as the PAHs that were to be analysed.

The chromatograms obtained showed traces of polycyclic aromatic hydrocarbons in several samples, with very low signal peaks, which confirmed the need to use the flame ionisation analysis (FID) method as the most efficient method to be followed for the analysis of PAH diffuse in air pollution, due to the fact that they are looking for quantitative pollutants in deficient concentrations.

The chromatograms produced by the analyses showed in Figures 4 and 5.

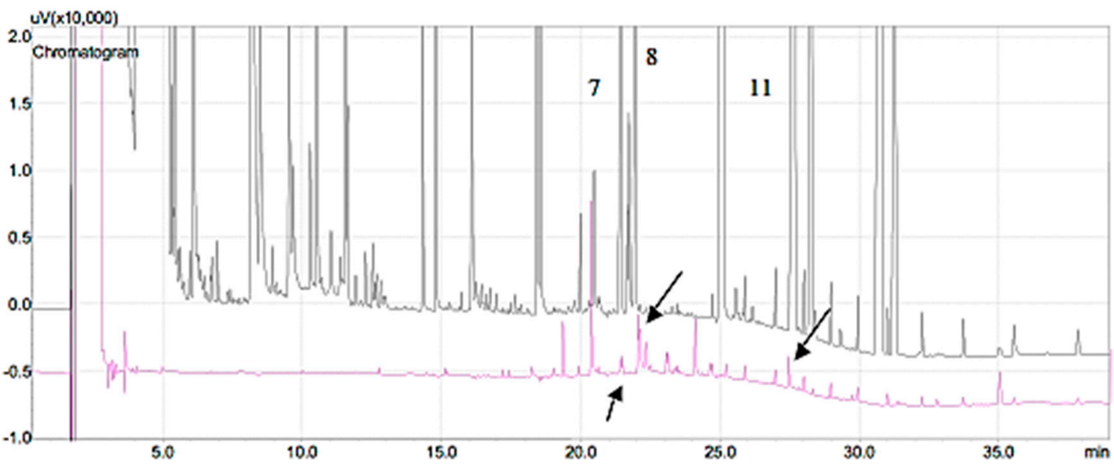

Figure 4. Chromatogram representative of SISCO installed on the pole in front of LAMES - Campus II of UFG.

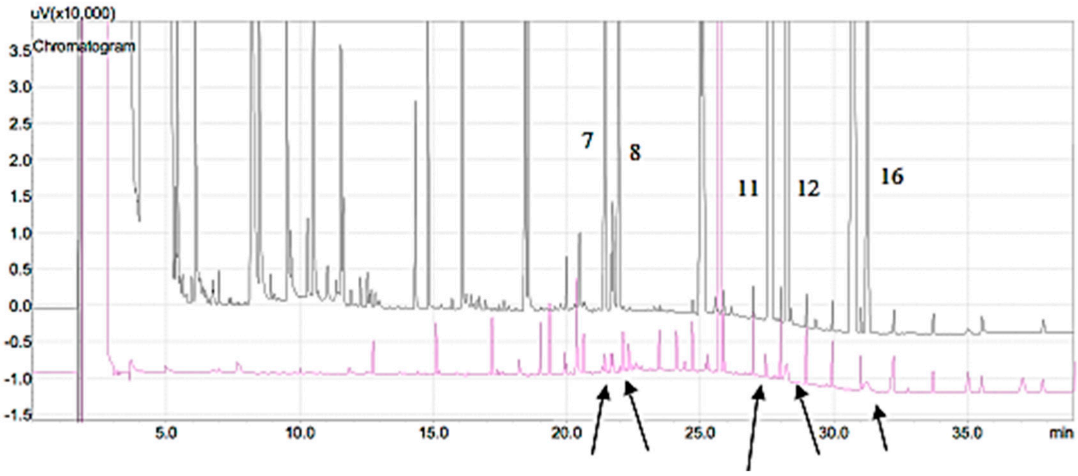

Figure 5. Chromatogram representative of SISCO installed in Independence Ave pole.

The chromatogram of Figure 4 was obtained by analysing the SISCO sample on a public lighting pole located in front of LAMES - Campus II of UFG, of which 3 PAH were detected.

The chromatogram of Figure 5 obtained by analysing the sample collected at the Airport Sector, in a public lighting post located at Avenida Independência, in the outskirts of Goiânia, where the presence of five PAHs were detected.

Of the 24 points whose passive GC / FID analysed atmospheric pollution sensors, 18 presented PAH traits.

Table 3 correlates the occurrence of PAH, distributed in the neighbourhoods of Goiânia, with the type of PAH analysed.

Table 3. An occurrence of PAH by sectors and occurrence index, with representation, with the indication of total frequency by location and by type of PAH analysed.

PAH	Naftaleno	Acenafteno	Fluoreno	Antraceno	Fenantreno	Fluoranteno	Pireno	Benz(a)antraceno	Criseno	Benzo(b)fluoranteno	Benzo(k)fluoranteno
Locals											
Praça Cívica 01 c/Rua 16											
Praça Cívica , n.º 565											
Rua 82, esquina c/ Rua 10											
Rua 96 c/Rua 97											
P. Universitária Campus I											
Praça da Bíblia											
UFG Campus II – LAMES							X	X			X
Perimetral Norte I											
Aeroporto S. Genoveva							X				X
Setor Criméia Leste											X
Praça do Cruzeiro					X						X
Setor Jaó											
Av. Perimetral Norte II											
FAMA								X	X		
Setor Aeroporto								X	X		X
Setor Oeste, rua 01								X		X	X
Setor Oeste – Zoológico											
Setor Marista								X			
CENG								X	X		X
Parque Areião											
Setor Pedro Ludovico								X		X	
Jardim Goiás											
Parque Atheneu										X	
Alphaville							X		X		X
APSOL II – lixo											
APSOL											
BT-153 (I)											
BR-153 (II)											
Jardins Atenas											
Occurrences					1		3	7	4	3	8

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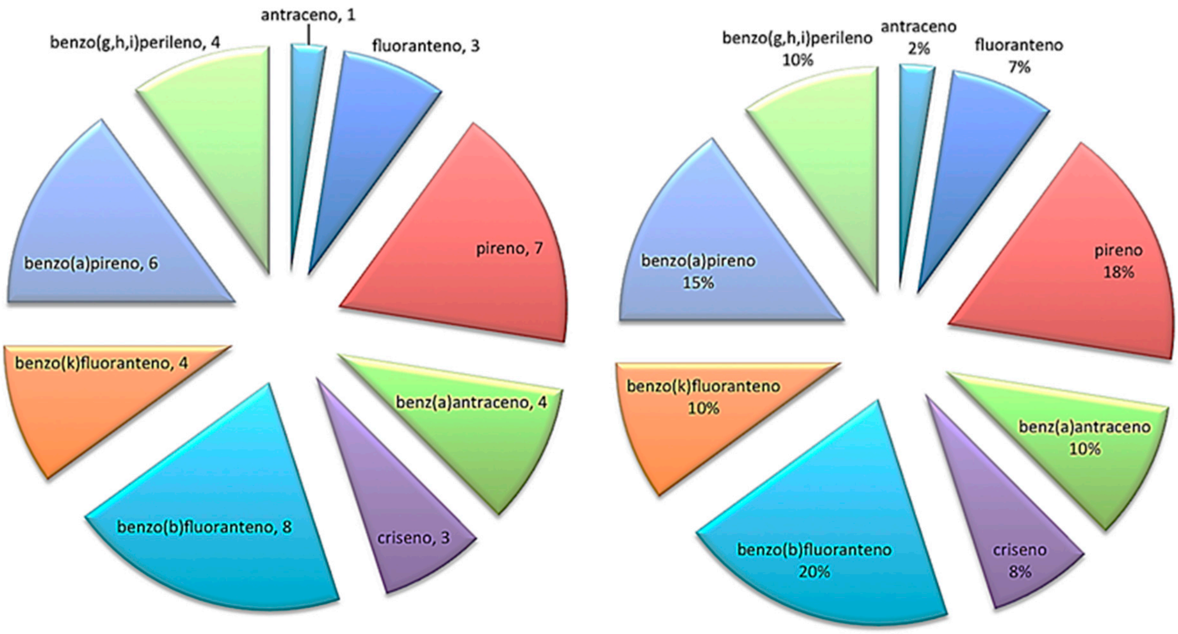
The PAHs founded in the atmospheric air of Goiânia were: anthracene; fluoranthene; pyrene; benz (a) anthracene; criseno; benzo (b) fluoranthene; benzo (k) fluoranthene; benzo (a) pyrene; benzo (g, h, i) perylene.

The benzo (b) fluoranthene was the PAH that had the highest number of occurrences, being present in 8 of the 24 analysed samples, presenting a percentage of 18% concerning the occurrences of PAH in all analysed samples.

The PAH that had the lowest occurrence was anthracene, and it was found in only one of the samples analysed, thus representing 2% of the total occurrences.

Figure 6a represents the PAHs founded in the analyses and band are plotted as a function of the incidence of each PAH, that is, the figures represent the relative frequency and percentage of PAH that was observed in the samples analysed.



(a) **(b)**

Figures 6a and 6b. Relative and percentage PAH indices, in neighbourhoods of the city of Goiânia, Goiás, Brazil.

Concern the place, the Airport Sector, where SISCO was established in the vicinity of typically industrialized sectors, was the point that presented the highest number of occurrences of PAH; followed by the West and Marist Sector, next to the Engineering Club; and by the points that were fixed in front of the LAMES, in Campus II of the UFG, Sector Pedro Ludovico and Residential Condominium Alphaville.

Figures 7a and b represent, respectively, the occurrence of PAHs separated by sectors; and the relative percentage of occurrence, also by sector of Goiânia.

The total PAH that were found, distributed by frequency and sectors and number of occurrences, is represented in Table 3.

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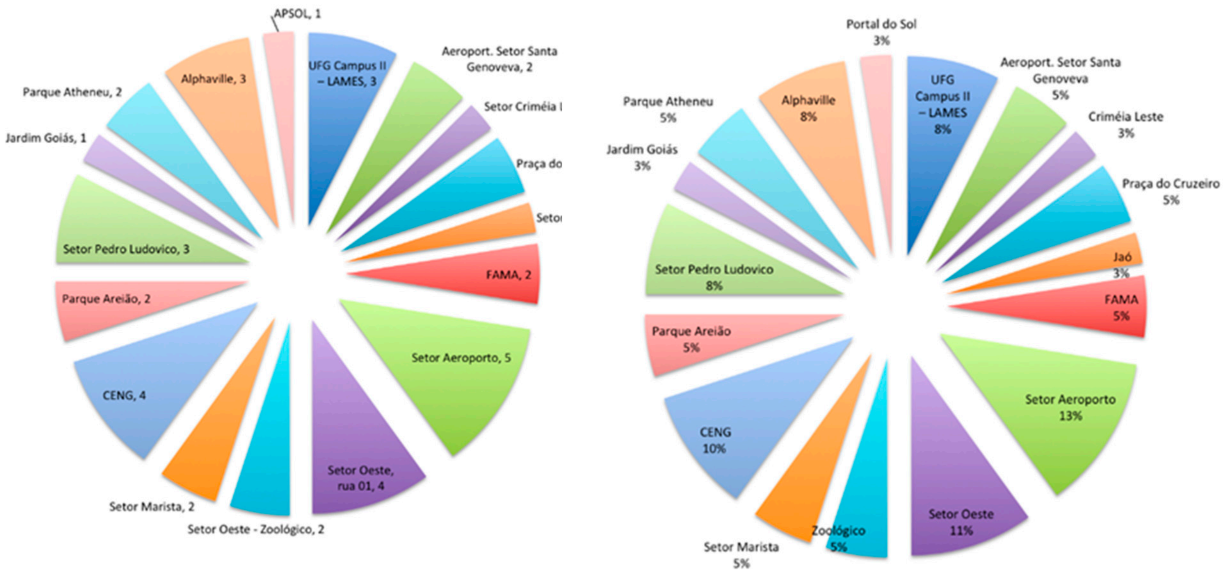

(a) (b)

Figures 7a and 7b. Percentage and relative occurrence indexes of PAH distributed by sectors of the city of Goiânia - GO, Brazil.

It was observed that the passive sensors that were placed in an urban environment, through the use of filter papers for adsorption of organic pollutants, proved to be useful for the detection of PAH in the environment-air.

At higher vehicle flow points, a higher incidence of PAH contamination was expected. However, the analysis of the results showed that in Praça Cívica; University Square; Southern Highway and Highway BR-153, there was no detection of PAH contamination in the samples that were analysed.

In the areas of high concentration and flow of vehicles within the city, there was probably no detection of PAH due to the circulating air flow, altered by buildings that form true canyons, which have a direct influence on the effects of atmospheric pollution, as observed by a mathematical modeling carried out in an urban environment, by Gallagher et. al. [14]

This fact is confirmed by the PAH index that was detected in more open places, where the SISCOs were established, such as in Campus II of UFG, and in the Sectors of Aeroporto, Oeste, Marista and Alphaville.

It is understood that the facilitated circulation of air by the adsorbent surfaces of the paper filters, placed in the SISCO, is the preponderant factor for the passive environmental monitoring through the proposed method.

More industrialised regions, such as the Airport Sector, where a SISCO was affixed to Av. Independência, which, in addition to the high flow of vehicles, is subject to the diffusion of particulates from processing industries in the region, with the highest incidence of occurrence of types of PAH.

The UFG Campus II region, where a SISCO was set in front of LAMES, despite being close to a green belt in the city, formed by UFG's reserve, due to the massive flow of public transportation buses, demonstrated the occurrence of 3 different PAH types.

Concerning the types of PAH found, the ones that presented more frequently distributed throughout the city - such as benzo (b) fluoranthene, pyrene, and benzo (a) pyrene - constitute PAHs typically resulting from the incomplete combustion of organic compounds, due to the multiplicity of aromatic rings, causes severe effects for human health with mainly carcinogenic effects.

The regions where the highest PAH levels were found correlate with the points where Brait [14] observed the highest presence of inorganic compounds, except for Praça Cívica, where there was a strong presence of metals in the work of Brait [19], while in the present the detection of PAH in that sector of the city, due to interference by urban canyons [14].

5. Conclusions

The passive monitoring system, by means of adsorption of organic compounds, through the fixing of sensors containing the filter paper, as an adsorbent element, is a simple, low cost method with the possibility of fixing in rural and urban environments, because the SISCO is fixed on poles intended for public illumination, which are present in practically all points where there is civilization, both in urban and rural environments.

According to EPA [27], the detection of the organic particulates, even in small quantities, constituting traces of organic compounds, demonstrates the effectiveness of the method, which has been able to detect the 16 PAHs most commonly found in air pollution.

Pollution by PAH in urban centres is diffusely present, given the volatility of organic compounds, contaminating the air-environment, not only in locations with higher concentrations of transformation and vehicle industries but also in more remote areas and even close to rural areas and green belts of cities.

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