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Concentration Level of Polycyclic Aromatic Hydrocarbons Emitted from Oud Incense: Al-Baha City, Southwest Saudi Arabia

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Abstract

Burning incense often produces air pollutants that may represent a health risk for humans. The Polycyclic Aromatic Hydrocarbons (PAHs) were identified in Oud incense which is matter of great concern because nowadays, incense is used inside homes as well as in public places and its adverse health effect cannot be ignored. Our main objective was to assess the concentration of individual PAHs compound in the smoke of Oud incence. The PAHs concentrations were determined by using High Performance Liquid Chromatography (HPLC). All Oud samples were collected from local market of Al-Baha city southwest Saudi Arabia. The total mean concentration of PAHs in Oud samples was 2.79 mg/m^3 and the mean concentration of individual PAHs namely naphthalene, acenaphthene, acenaphthylene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(b)fluoranthene and benzo(a) pyrene was 0.10, 0.26, 1.22, 0.12, 1.06, 0.02, 0.32, 0.26, 0.03, 0.10, 0.08 and 0.18 mg/m^3 respectively. The highest values of total PAHs were 5.72 and 4.05 mg/m^3 found in samples 5 and 7 respectively and the lowest total concentration of 1.25 mg/m^3 was found in sample 3. The dominant PAHs were acenaphthylene, fluorene, phenanthrene, fluoranthene and pyrene.

Keywords: Oud incense; PAHs; HPLC; Al-Baha City

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are large group of organic compounds with two or more fused aromatic ring. These compounds are solids with low volatility at room temperature. They are relatively insoluble in water and most can be degraded to simpler substances. Regulatory agencies such as US environmental protection agency (EPA) and agency for toxic substances and disease registry (ATSDR) have defined maximum allowable level of PAHs in the environment due to their adverse health effect to human [1]. Exposure to PAHs can occur from different sources such as water, food and air [2-5]. Incense burning is associated with many culture and ceremonies in many countries. The incense materials are used to fragrant the environment and most of the people do not know that this fragrant may cause indoor air problems. Different carcinogenic substances have been detected in incense smoke [6-9]. The exposure to incense smoke have been found to make lung cancer, asthma, headache, nausea and allergic to skin and eyes [10-12]. One of the suggestions to prevent lung cancer in the community should include the reduction or minimization of exposures to indoor air pollutants [13]. Beside PAHs, incense burning was found to be the significant source of particulates, heavy metals and volatile organic compounds [14-17]. One of the most widely used incense in all Arab Gulf region is Oud (or Oudh) which have been used as a fragrant in home and all other traditional ceremonies. Other names for Oud are agarwood, jinkoh, agar and aguru. Active components available in oil extract from agarwood have been studied [18-20]. Our previous study [21] had prove the presence of PAHs in Oud incense, and our aim in this article was to determine the concentration level of each PAH present in seven different types of Oud incense widely used in Al-Baha city and compare it to the allowable PAHs level given by different environmental agencies.

Materials and Methods

Oud samples selection

Oud incense samples have been collected from local market of Al-Baha city. Table 1 presents the trade names and country of origin of each Oud sample.

Sample No	Trade name	Country of origin
1	Oud 350	Cambodia
2	Oud 2002	Cambodia
3	Oud 1000	Cambodia
4	Oud 500	Cambodia
5	Oud super 2080	India
6	Oud ceufi malaki	India
7	Kalmentan	India

Table 1: Trade names and country of origin of Oud samples.

Sampling process

As described in our previous studies [6,21], the burning test system consists of burning unit and sampling chamber. PAHs pollutants produced during oud burning flow directly into the sampling chamber (steel cylinder with an internal diameter of 10 cm and height of 100 cm). High efficiency particulate air (HEPA) filtration system has been used to remove any particles from air before entering in to the test chamber. A known weight of Oud incense was placed in the combustion unit which was connected to the sampling chamber. The exit airflow rate was 4 L/min. A zefluor membrane filter (47 mm, 0.5 µm, P5PQ047, Pall, USA) with 47 mm in-line filter holder (stainless steel, 2220, Pall, USA) was used to collect PAHs for 20 min. Each tested sample was analyzed three times to ensure representative samples. The membrane filter was soxhlet extracted with methylene chloride for 15 h before use.

Extraction of PAHs

The PAHs were extracted as follows: the filter was inserted into

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a 50-ml brown sampling vial followed by extraction using 40 ml dichloromethane (analytical grade, Aldrich Chemical Co. Ltd) in an ultrasonic bath for 15 min. This extraction was repeated three times to ensure complete extraction. The resultant solutions were filtered through a pre-cleaned pasteur pipette filled with solvent-rinsed glass wool, dried with anhydrous Na_2SO_4 (12–60 mesh, analytical grade, Loba Chemie Pvt. Ltd), and concentrated by a rotary evaporator in a thermostatic bath at 35°C. The final volume, about 2-3 ml, was further reduced to 1 mL under a gentle nitrogen flow.

High Performance Liquid Chromatography (HPLC) analysis

The test method used for quantification of PAHs was ISO 15753:2006 [22]. The PAHs extracts were analyzed by HPLC equipped with fluorescence detector. Analytical column PAH C18 5 µm (3.0 × 250 mm), solvent mixture A: acetonitrile and B: acetonitrile/ water (50:50) were used as a mobile phase at a flow rate of 0.6 ml/min. Sample of 20 µL was injected into the column through the sample loop. All data for quantification of the PAHs were obtained by applying the gradient elution program shown in Table 2 at a controlled oven temperature of 25°C. The optimal wavelengths for excitation and emission were found by peak scanning (Table 3). The quantification of the PAHs was made by using standard solutions as follows: standard stock solution (10 mg/L), intermediate standard solution (200 µg/L in acetonitrile), working standard solution (50 µg/L in acetonitrile). The peaks were identified based on their retention times, emission, and excitation spectrum which comparable to the reference spectra (Figure 1). The mean recovery value of PAHs using this method was 70–110%.

Results and Discussion

The PAHs found in the seven Oud incense samples were naphthalene, acenaphthene, acenaphthylene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(b)fluoranthene and benzo(a)pyrene. The total mean concentration of PAHs in Oud samples was found to be 2.79 mg/m^3 and the mean concentration of individual PAHs namely naphthalene, acenaphthene, acenaphthylene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(b) fluoranthene and benzo(a)pyrene was 0.10, 0.26, 1.22, 0.12, 1.06, 0.02, 0.32, 0.26, 0.03, 0.10, 0.08 and 0.18 mg/m^3 respectively, shown in Table 4. The highest total concentrations of PAHs of 5.72 and 4.05 mg/m^3 were found in samples 5 and 7 respectively. The lowest total concentration of 1.25 mg/m^3 was found in sample 3. The total PAHs concentration in Oud incense samples was higher than the allowable level given by different environmental agencies. The occupational safety and health administration (OSHA) permissible exposure level for PAHs in the workplace is 0.2 mg/m^3 for 8-hour workday [23]. The national institute for occupational safety and health (NIOSH) has recommended the workplace exposure limit for PAHs be set at the lowest detectable concentration which is 0.1 mg/m^3 recommended exposure limit for a 10-hour workday [24]. The American conference of governmental industrial hygienists threshold limit value of PAHs is 0.2 mg/m^3 recommended for a normal 8-hour workday [25]. Naphthalene was found in samples 4, 6 and 7 with highest concentration of 0.24 mg/m^3 in sample 7. The reference dose for oral exposure of naphthalene which reported by IRIC, EPA is 3×10^{-3} mg/m^3 [26]. benzo(a)anthracene, benzo(b)fluoranthene and benzo(a) pyrene were found in sample 1 and 4. The highest concentration of benzo(a)pyrene (0.21 mg/m^3) was found in sample 4 which exceed the allowable reported level. The target annual mean values of benzo(a)pyrene of 0.7 to 13×10^{-7} mg/m^3

Time (min)	Solvent mixture A	Solvent mixture B
0	0	100
5	0	100
27	60	40
36	100	0
41	100	0
43	0	100
45	0	100

Table 2: Gradient elution program on C_{18} column.

Detected Group	Time (min)	Excitation wavelength (nm)	Emission wavelength (nm)
Naphthalene Acenaphthene Fluorine	0	270	324
Phenanthrene Anthracene	12,6	248	357
Fluoranthene	16,4	280	462
Pyrene Benzo(a)anthracene Chrysene	18,05	270	385
Benzo(b)fluoranthene	28	256	446
Benzo(k)fluoranthene Benzo(a)pyrene Dibenzo(a,h)anthracene Benzo(g,h,i)perylene	31,1	292	410
Indeno(1,2,3-c,d)pyrene	38	274	507

Table 3: Programme of excitation and emission wavelength pairs.

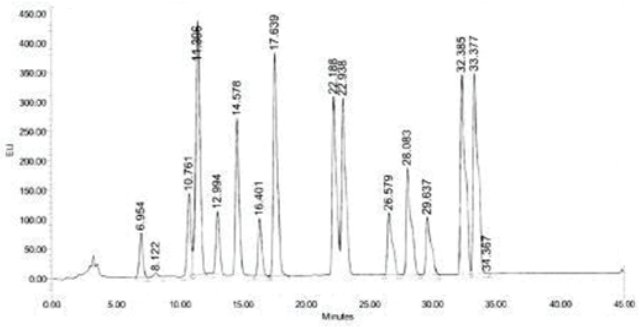

Figure 1: Typical chromatogram of PAHs standard mixture. Peaks: 1- Naphthalene, 2- Acenaphthaylene, 3- Acenaphthene, 4- Flourene, 5- Phenanthrene, 6- Anthracene, 7- Flouranthene, 8- Pyrene, 9-Benzo(a)anthracene, 10- Chrysene, 11- Benzo(b)fluoranthene, 12- benzo(k)flouranthene, 13- Benzo(a)pyrene, 14- dibenzo(a,h)anthracene, 15- Benzo(g,h,i)perylene, 16- Indeno(1,2,3-cd)pyrene.

PAHs	1	2	3	4	5	6	7	Mean
Naphthalene	ND	ND	ND	0.05	ND	0.02	0.24	0.10
Acenaphthene	0.48	–	–	–	–	–	0.04	0.26
Acenaphathylene	ND	1.04	0.58	0.36	3.13	1.02	1.18	1.22
Fluorene	0.04	–	–	0.03	0.38	0.04	–	0.12
Phenanthrene	0.37	0.87	0.67	0.18	2.21	0.82	2.32	1.06
Anthracene	0.004	–	–	0.02	–	0.04	–	0.02
Fluoranthene	0.24	0.56	–	0.18	–	0.33	0.27	0.32
Pyrene	0.09	0.38	–	0.23	–	0.35	–	0.26
Chrysene	0.02	–	–	0.04	–	–	–	0.03
Benzo(a) anthracene	0.12	–	–	0.08	–	–	–	0.1
Benzo(b) fluoranthene	0.06	–	–	0.09	–	–	–	0.08
Benzo(a)pyrene	0.14	–	–	0.21	–	–	–	0.18
∑ PAHs	1.56	2.85	1.25	1.48	5.72	2.62	4.05	2.79

Table 4: Concentration of PAHs (mg/m^3) in Oud incense samples.

established by European countries [27]. WHO recommended a health based guideline value of 1×10^{-6} mg/m^3 benzo(a)pyrene for ambient air [28] and a value of 1.1×10^{-6} mg/m^3 inhalation unit risk estimate calculated by California environmental protection agency [29]. In addition benzo(a)pyrene is often used as a marker for total exposure to carcinogenic PAHs as its contribution to the total carcinogenic potential is high [30].

Conclusion

The PAHs found in the seven Oud incense samples were naphthalene, acenaphthene, acenaphthylene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(b)fluoranthene and benzo(a)pyrene. The concentration of PAHs in the Oud incense samples was greater than the allowable level given by different environmental agencies. The total mean concentration of PAHs in Oud samples was found to be 2.79 mg/m^3. The highest values of 5.72 and 4.05 mg/m^3 were found in samples 5 and 7 respectively and the lowest total concentration of 1.25 mg/m^3 was found in sample 3. Burning incense is a common practice that companied with different ceremonies in many areas especially Middle east. Incense smoke remains throughout the day which increases duration of exposure to the toxic substances. Incense smoke as reported by many authors is one of the important indoor pollutants since it contains PAHs which have been classified as most pollutant compounds. The EPA (1994) has classified PAHs as a B-2 pollutant that means probable human carcinogen [31].

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