Bull. Environ. Contam. Toxicol. (1988) 41:449–453

Bulletin of Environmental Contamination and Toxicology

Occurrence of Benzo[a]pyrene in Combustion Effluents of Kerosene and Diesel Burners

S. H. Gharaibeh,* M. A. Abuirjeie,** and A. A. Hunaiti***

*Department of Earth and Environmental Sciences, Yarmouk University, Irbid; **Department of Medicinal Chemistry, Faculty of Pharmacy, Jordan University of Science and Technology, Irbid, and ***Department of Biological Sciences, Yarmouk University, Irbid, Jordan

Due to limited Jordanian resources, kerosene and diesel burners have been widely used for heating homes and water, warming bread, grilling meat and cooking food. Jordan annually imports an average of 204 tons of burners which corresponds to approximately 20,400 burners. Some of these burners are manufactured locally while others are imported from Japan, South Korea, Syria, Iraq, and other countries.

Considerable amounts of combustion products are produced such as gasses, aerosols and polycylic aromatic hydrocarbons (PAH), especially benzo[a]pyrene (Bp), the well known carcinogen for man and animal (Schlipkoeter 1970). Since most Jordanians use burners more than five months per year, a considerable amount of combustion effluents accumulate indoors. Some of these materials can enter the human body via various routes, and are potential health hazards. Little information is available about the chemical nature and amount of the combustion effluents produced by these burners; therefore the present study was designed to screen for benzo[a]pyrene in the indoor-accumulated combustion effluent.

MATERIALS AND METHODS

Benzo[a]pyrene was obtained from Sigma Chemical Company (U.S.A.). All reagents used were of analytical grade; solvents for HPLC analyses were of high purity and were filtered and degassed prior to their use. Thin layer chromatography (TLC) plates (20 cm x 20 cm x 0.25 mm) were obtained from Whatman, New Jersey, (U.S.A.).

Send reprint request to Gharaibeh, S.H. at the above address.

An HPLC system composed of a solvent delivery pump (Model 114 M, Beckman), an injection valve (Beckman), a variable wavelength detector (Model 165, Beckman), and an integrator-plotter (Sp 4270) was used. A 250 x 4.1 mm i.d. Stainless steel column (Beckman U.S.A.), Synchropack C-18-Rp, 5.6 u provided with a guard column at ambient temperature was used in this study.

One hundred samples of solid deposits (soot) of combustion effluents, from kerosene and diesel burners, were collected from randomly chosen residences. The collected samples were separately weighed. During sample collection, care was taken to avoid contamination with the inside paint of the burners. Two grams of each sample were placed in 20 mL of methanol in a glass beaker and stirred vigorously for 30 min. The undissolved materials were removed by filtration through a Buchner funnel lined with Whatman No. 3 filter paper. The filtrates obtained were concentrated to a minimum volume of 1.0 mL by evaporation of the methanol under nitrogen. The sample extracts were spotted on silica gel plates (20 cm x 20 cm) along with standard Bp. Two mobile phases were used; solvent A consisted of 95% : 5% (v/v) pentane: ether and solvent B consisted of 80% : 10% : 10% (v/v/v) n-butanol: acetic acid: water. Benzo[a]pyrene spot was visualized under UV light and extracted by methanol (3 x 3 mL). The extract was concentrated to 2 mL by evaporation of methanol under nitrogen for further HPLC analyses. Twenty microliters of the concentrated sample extracts were injected into an HPLC fitted with a C-18-Rp column which was previously equilibrated with 75% : 25% (v/v) acetonitrile: water pH 8.4. The samples were eluted with the same solvent at 2.5 mL/min. Monitoring the effluent was done at 254 nm. Under identical conditions standard Bp (170 ng dissolved in 20 uL of acetonitrile) was also injected into the system.

RESULTS AND DISCUSSIONS

TLC and HPLC analyses showed that benzo[a]pyrene was present in all samples collected from various kerosene and diesel burners. With TLC, two different solvents were used and the relative mobilities (RF) values for the tested samples in each solvent were found to be 0.8 ± 0.05 and 0.4 ± 0.03 in solvent A, and B, respectively These values are identical to Rf values of pure Bp tested under identical conditions. These preliminary results suggested the presence of Bp in all samples and reproducible results were obtained for at least four times for each sample.

HPLC analyses confirmed this finding. In order to achieve a better resolution of the eluents from the tested samples, various solvent compositions were tried. Optimum analyses was obtained when a mobile phase consisting of 75% : 25% (v/v) acetonitrile: water was used. Upon injection of 170 ng of pure Bp, a well defined peak emerged at about 16 min (Fig. 1,a). Samples analysed under similar conditions gave peaks at the same retention time. Figure 1 (bI and bII) shows such a result for combustion effluents obtained from kerosene and diesel burners, respectively. Further confirmation for the presence of Bp was obtained by chromatography of a known amount of Bp standard with a known amount of a sample from a kerosene burner. A single sharp peak at a retention time of 16 min was obtained (Fig. 1,c). Our findings were similar to previously reported results which demonstrated the presence of PAH including Bp in petroleum products (Badger and Spotswood 1971, Li Yu and Hites, 1981, Suess 1976).

In an attempt to quantify the amount of Bp in various samples obtained from burner effluents operating on kerosene and diesel, peak height ratios of sample to standard were used. Kerosene burner samples were found to contain 8.5 ± 0.5 ug of benzo[a]pyrene per gram of crude combustion effluent while diesel burner samples were found to contain 3.7 ± 0.4 ug of benzo[a]pyrene per gram of combustion effluent. The percentage of Bp in kerosene burner samples (80/100) was about two times that of diesel burner samples (20/100).

Statistics of the General Statistical Directorate showed annual importation of 20,400 /year of portable burners, operating on kerosene and diesel, from various countries into Jordan. In addition 8000/year of these burners are produced locally (Jordan General Statistical Directorate Reports 1980-1986). The statistics of the Jordan Petroleum Refinary showed that 135,000 metric tons/ year of kerosene are consumed for heating homes and industries (Jordan Petroleum Refinary Reports 1980-1986). This information indicated that more than 85% of Jordanians use portable burners to heat their homes. In addition, they warm water, bake bread, grill meats and cook their food with these burners. Prolonged use of these burners for heating and cooking, subjects people to health hazards from the combustion effluent particulates which contain Bp as the present study showed. These particulates can enter the body by one or more of the following ways:

a. Inhalation of the small particles into the lungs.
b. Ingestion of food, especially warmed bread and grilled meat.
c. Dermal absorption.

It is worth mentioning that penetration of combustion effluents through skin increases in the presence of detergents (Borneff 1967). As an example, after cleaning the burners with bare hands, the use of detergents helps penetration of Bp through skin into blood.

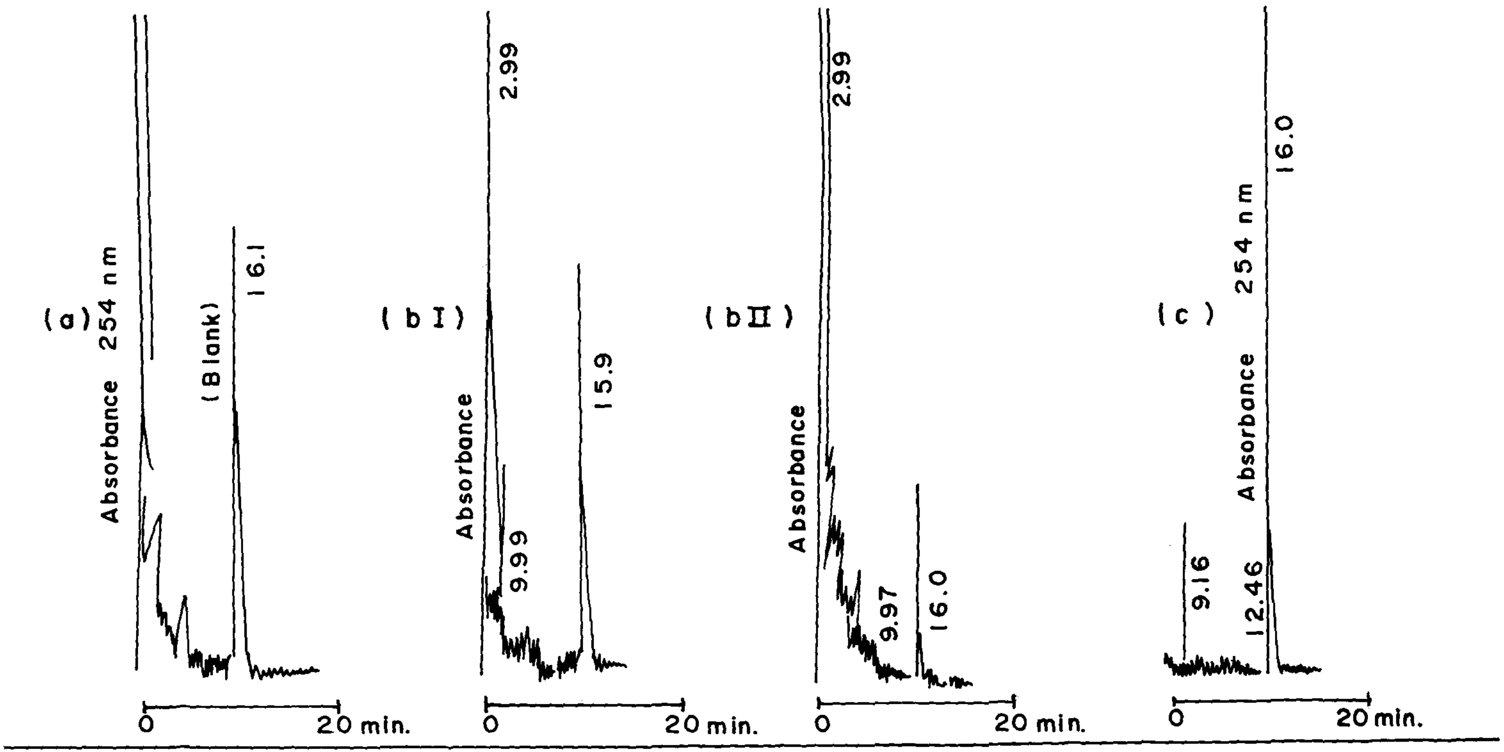

Figure 1. HPLC chromatogram using 75%:25%(v/v) acetonitrile : water. (a) pure benzo[a]pyrene (b) samples from combustion effluents of kerosene (bI) and diesel (bII) burners. (c) pure benzo[a]pyrene and kerosene burner sample mixture.

The present study showed the presence of Bp in relatively high concentrations in combustion effluents. These burners can be an important source for human health hazards in countries where kerosene and diesel burners are extensively used.

REFERENCES

Badger GM, Spotswood TW (1960) The Formation of Aromatic Hydrocarbons at High Temperatures. J Amer Chem Soc 82:4431-4433.

Borneff J (1967) Vorkommen und Bewertung von Kanzerogenen Substanzen in Wasser. Gas-und Wasserfach 108:1072.

Jordan General Statistical Directorate Reports 1980-1986, Jordan-Amman.

Jordan Petroleum Refinery Co. Ltd. General Reports 1980-1986, Jordan-Amman.

Li Yu M, Hites RA (1981) Identification of Organic Compounds on Diesel Engine Soot. Anal Chem 53:951-956.

Schlipkoeter HW (1970) Wirkung von Luflverunreinigungen auf die menschliche Gesundheit. Hrsg. Minister F. Arbeit, Gesundheit und soziales des Landes NRW Germany S1.

Suess M (1976) The Environment Load and Cycle of Polycyclic Aromatic hydrocarbons. Sci Total Environ 6:239-250.

Received January 19, 1988; accepted March 16, 1988.