LABORATORY INVESTIGATION OF CHEMICAL POLLUTANTS IN THE INDOOR/OUTDOOR AIR OF HOMES

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Abstracts - Activities in the Indoor Environment together with the inward infiltration of outdoor pollutants results in the increased concentrations of various pollutants in indoor air of homes lead to increased exposure to airborne pollutants by the inhabitants and possible health effects. Airborne samples were collected from various locations indoors/outdoors in some Nigerian homes: actively using standardized pumps and via diffusive methods and the presence of organic chemical pollutants emissions were investigated using Thermal Desorption-Gas Chromatography-Mass Spectrometry(TD/GC/MS). The Results demonstrated that emissions from the various anthropogenic activities indoors contain chemical pollutants which are contributory sources of human exposure to environmental pollutants

Keywords - Indoor/Outdoor, Chemical Pollutants,

I. INTRODUCTION

People in the Damaturu community of north-eastern Nigeria spend most of their time indoors because of the harsh weather conditions: cold, dry, strong, and dusty wind during Harmattan, thick dust during storm, and heavy downpours during the rainy season. The habit of using fire wood and kerosene in cooking, and diesel/petrol powered generators for electricity are potential factors of increased indoor pollution including dust particulate deposition which may linger in the air or cling to dust particles and settle on raised surfaces and floors [1].The pollutants present in air may potentially cause exposure via inhalation and ingestion of house dust particles adhering to food and objects, or via direct absorption through the skin[2]. The natural and anthropogenic sources of airborne and deposited dust are a risk to the health of the local population amongst which there is a
general acceptance of the adverse outcomes as these are considered arisingfrom natural phenomena and thus a situation that cannot be changed.
Much of the concern about health risks from airborne particulates and dust is thought to be dueto the organic compounds contained within [3]. Phthalates and phosphate esters are SVOCs known to adsorb to solids such as airborne particles and settled dust and to partition between gaseous and particulate phases, which may have both short term, and cumulative health effects [4],[5]. The growing concern about the impact that chemicals in the household environment have on our health has led to increased studies over the years (carried out by organisations such as the Worldwide Fund for Nature (WWF) and Greenpeace) to assess the levels of chemicals in homes, and their potential consequences for individuals on exposure[6].
Many organic chemical contaminants are irritants to the eyes and mucous membranes; mixtures of different VOCs at low levels are capable of acting synergistically to elicit neural behaviours [7],[8]. An association between phthalates exposure and endocrine disruption and cancer have been reported by several in-vivo studies [9],[10],[11]. In an observational study by [12], it was reported that indoor biological and chemical agents causing short term respiratory and inflammatory health effects may potentially lead to chronic, long term health impacts and health effects which may be experienced soon after exposure or, possibly, years later.Airborne samples were collected by standardized pumped and diffusive methods in order to investigate possible sources of chemicals in the indoor/outdoor environmentinDamaturu town, northern Nigeriaand the presence of organic chemical contaminants was quantified.

II. METHODOLOGY

Diverse means of collecting airborne particles and vapours both passively and actively within the indoor/outdoor environments have been developed and employed by different researchers depending on the availability andsuitability of the equipment for the sample and type of analysis to be carried out[1].
we used the standard method of sampling and analysis of volatile organic compounds in air adopted from the international standard BS EN ISO 16017-2 using sampling tubes loaded with sorbent and analysed by TD/GC/MS [13]. We carried out the air sampling during various domestic activities; cooking with kerosene stoves, cooking with gas stove, and firewood; electricity generation with fossil fuels (petrol and diesel) and natural weather (dusty events) and the tubes were analysed by TD/GC/MS.

2.1 Diffusive (Passive)

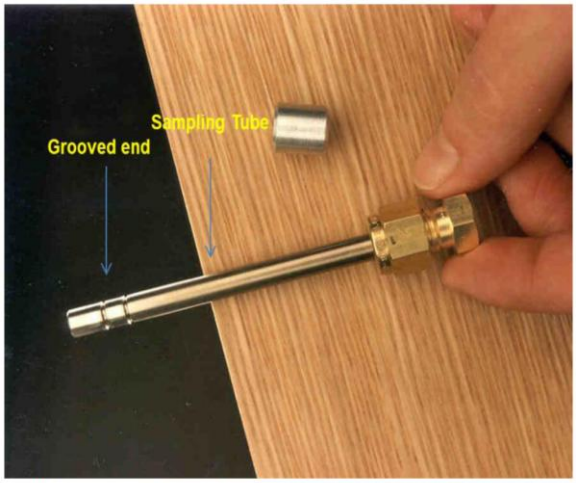
Samples were collected passivelyby opening the grooved end of the tube and placed on raised undisturbed indoor locations for 2 weeks to allow the

sampling of the VOCs and SVOCs by diffusionwith a typical airsampling rate equivalent to 0.5 to 1 ml min^{-1} (depending on the compound). The equivalent of approximately 10.8 litres of air is sampled by each Tenax tube, although transport of chemicals into the tube is by diffusion rather than air flow. Each tube was closed after the sampling period, wrapped in foil paper, and transported to the laboratory for analysis.Two tubes were kept closed as field blanks.The samples were collected during various human activitiesfrom homes. The equivalent air volume sampled = 0.5 X 60 X 24 X 14 = 10080 ml= 10.08 litres.

2.2 Active (pumped) sampling

Active samplingwas done by opening a pre-conditioned sorbent tube (quartz-Tenax), connecting it to a sampling pump(TSI-side-pak (sp-700), and pulling air through the tube with the pump at a flow rate volume of 200 ml min^{-1} for 10 minutes during each sampling where airborne chemicals are trapped onto the surface of the sorbent. A total of 200 ml X 20 min. = 4 litres of air was sampled through each of the sorbent tubes.The tubes were then sealed with push-on caps. The method was in accordance with an international standard [14]. The sampling was carried out during the same events in the diffusive sampling above.

The sorbent tubes containing sampled air were then taken to the laboratory and spiked with an internal standard d-toluene prior to TD/GC/MS analysis and the organic chemicalsquantified.



Collection of airborne vapours/emissions on sorbent tube

III. RESULTS

The presence of an array of organic chemicals was observed and the chemicals of interest (target chemicals) were quantified. Chemical emissions were observed in all the samples analysed as seen on the chromatograms in both diffusive and pumped samples.The target chemical concentrations in ng l^{-1} showed high concentrations of chemical emissions especially during cooking with firewood and kerosene stove; and during diesel electricity generation.The target chemicals of focus are shown in Table 1. The example of chromatograms showing a wide range of chemicals with different retention times in both diffusive and pumped samples are shown in Figures 1 and 2.

Chemical	Characteristics	Uses	Health effect
Alkyl aldehydes-Nonanal, Hexanal,	Ubiquitous constituents emitted into the atmosphere from the incomplete combustion of biomass and fossil fuels.	Used in the flavour industry to produce fruity flavours.	Eye and mucous membrane irritants
Benzene	Used mainly as an intermediate to make other chemicals used to make polymers and plastics.	Used in rubbers, lubricants, dyes, detergents, drugs, explosives, napalm, and pesticides. Benzene is formed during fuel combustion.	Carcinogenic
Phthalate esters-DBP, DEP, DIBP, DEHP (CDC, 2011; Mercier et al., 2011)	DBP has a faint, disagreeable odour and can be transferred from the plastics that contain it.	Used as additive to adhesives, printing inks, plasticizer in plastisols (for example in toothbrushes, textile paint, food packaging and toys), nail polish, explosive material and as solvent.	Produce toxic gases, irritants, and endocrine disrupters.
Limonene (monoterpene) (Nilsson et al., 1998)	Occurs in citrus peel, and it has a strong generic citrus smell.	Widely used as a flavour and fragrance additive in cleaning and cosmetic products, food and pharmaceuticals. It is also present in most of the essential oils.	Contact with limonene or limonene products can cause eye and skin irritation.

Table ITarget organic chemicals quantified (various sources)

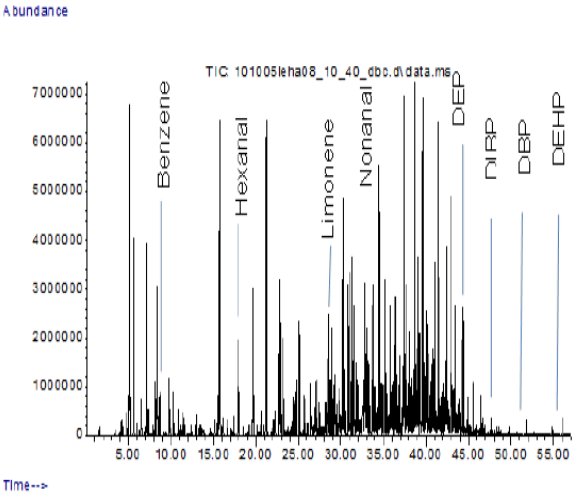


Figure 1 Chromatogram of diffusive indoor sample

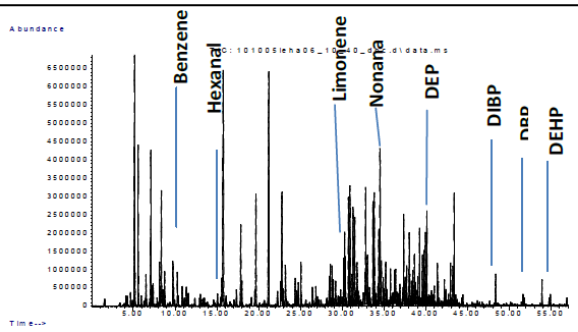


Figure 2 Chromatogram of active outdoor sample

The total volatile organic compounds (TVOCs) calculated gave an indication of presence of a host of chemicals in the samples in addition to thetarget compounds.

Total volatile organic chemicals (TVOC) valuesthe sum of all VOCs found with volatilities between those of n-hexane and n-hexadecane quantified using the calibration factor for toluene, were determined for all the samples.

The TVOCs were calculated based on the presence of many compounds observed in the chromatograms. The identification and quantification of all individual VOCs occurring in air samples is difficult, if not impossible. The

Compound	Chemical concentrations ng l^{-1}		
	Kerosene cooking	Gas cooking	Firewood cooking
Benzene	29	8	212
Hexanal	2	6	5
Limonene	10	5	3
Nonanal	11	3	7
DEP	2	1	6
DIBP	1	11	56
DBP	1	21	4
DEHP	0.5	2	6
TVOCs	2395	417	1530

Table 2. Chemical concentrations and TVOCs in pumped air samples during various activities

Compound	Chemical concentrations ng l^{-1}			
	Diesel generator	Petrol generator	Harmattan haze	Storm episode
Benzene	4	250	1	7
Hexanal	2	2	0.5	30
Limonene	3	10	1	17
Nonanal	8	4	5	41
DEP	2	1613	0.5	8
DIBP	<1	36	0.5	<1
DBP	3	2	0.5	<1
DEHP	5	1	0.5	<1
TVOCs	18060	6331	152	380

Table 3. Chemical concentrations and TVOCs in pumped air samples during various activities

TVOC values were taken as a simplified way of expressing the results of VOCs measurements and this has been adopted by many researchers as an indicator of air quality, and as a predictor of the probability of health and comfort effects (Brown et al., 1994). A measure of the TVOCs quantity is defined as all VOCs in the boiling point range of 50–260°C [16]. The TVOCs (ng l-1) of airborne samples collected actively (pumped) during household activities showed highest concentrations especially during burning/use of fossil fuels in cooking and electricity generation. The results obtained in this study established that the airborne particulates in Damaturu contain a host of pollutants, which can cause various health effects from irritations, to systemic effects and endocrine disruption when the people in the community are exposed to the dusts.

The mean chemical concentrations were observed in higher amounts in the indoor than in the outdoor samples, and DEHP was more than the other compounds. The high DEHP emissions may be due the fact that it is the most common plasticizer found in almost all plastic and most household products.

The problem of indoor/outdoor pollution from the use of domestic cooking stoves has attained greater importance in developing countries owing to poor ventilation and the extensive use of low-efficiency stoves and biofuels [15].

IV. CONCLUSION

The increasing recognition of the importance of the indoor environment in the developed as well as the developing countries has led to a wide range of studies that investigated the impact of air pollution on health. There is a lot of work reported about activities such as cooking and electricity generation using biomass fuels and fossilfuels as producing high amounts of environmental pollutants posing high levels of human exposure to the various pollutants. There is also evidence of health effects associated with weather events that produce high concentrations of particulate matter and heavy deposition of dust[16].

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