Pollution Impacts of Cigarette Consumption on Indoor Air Quality in Nigeria

K. Ebisike, [1]O.O. Ayejuyo, [2]J.A. Sonibare, [3]O.A. Ogunkunle and T.V. Ojumu
Engineering Materials Development Institute, P.M.B 611 Akure, Nigeria
[1]Department of Chemistry, Lagos State University, Lagos, Nigeria
[2]Department of Chemical Engineering, Obafemi Awolwo University, Ile-Ife, Nigeria
[3]Department of Chemistry, Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract: The quality of air available indoor calls for more attention now than ever because of several findings confirming that up to 85% of time can be spend indoors by man. Environmental tobacco smoke emanating from cigarette consumption is one of the most common indoor air pollutants. In this study, the trace elements content of six common brands of cigarette produced, marketed and consumed in Nigeria were examined using Atomic Absorption Spectrophotometer (AAS). Unsmoked butt, smoked butt, tobacco, ash, urine and saliva of some smokers and non-smokers were analyzed for five selected trace elements (Pb, Zn, Cu, Cd and Ni). These trace elements were detected in all the cigarette samples-both smoked and unsmoked butt, tobacco, ash, smokers' urine and saliva analyzed. Though Pb, Zn, Cu and Cd were detected in the non-smokers' urine samples, their concentrations were about 66-99.3% less than that of smokers' samples concentration. Only Cu was detected in non-smokers' saliva but this was about 75% less than the smokers' level. Toxicity potential of these trace elements, if their detected concentration in the Six brands of cigarette considered, could find their ways into the indoor air is an indication that cigarette consumption in Nigeria could impact negatively on the indoor air quality where cigarette smoking often takes place. Adhering to the 'non-smoking' warning of the Federal Ministry of Health in the country is a possible way of combating this.

Key words: Trace elements, cigarette, environment pollution, smoke, tobacco, particulates

INTRODUCTION

Tobacco consumption worldwide is an identified problem that must be solved before its destructive impact on the environment does irreparable damages. To do this, several efforts are on to provide scientific reasons on its negative implication. Variation in formulation of cigarette (a form of tobacco consumption) according to manufacturers makes chemical analysis of different portion (tobacco part, smoked filter and unsmoked filter) of common brands in a particular country, a worthwhile exercise. Information from such an exercise could assist in proper air quality management for human protection.

Cigarette is one of the means by which nicotine in tobacco is made available for human consumption[1]. Usually, it is made up of tobacco, paper and additives. The most common form of tobacco use is the manufactured cigarette[2] and in the history of air pollution, environmental tobacco smoke (ETS) generated during cigarette consumption has been found to contribute greatly to environmental pollution via air contamination. Cigarette smoke contains particles and gases generated by the combustion of its various components at high temperature and it can be inhaled directly by smokers or by nonsmokers in cigarette contaminated environment through "passive smoking"[3]. Air pollution by cigarette smoke could be of great concern especially in an environment with poor ventilation due to the negative influence this might have on indoor particle and gas concentration[4].

Tobacco consumption through cigarette smoking is a problem assuming an alarming proportion in Nigeria. In 1990 about 21,220 ha were harvested for tobacco in the country. Between 1990-1992, about 2,400 tones of unmanufactured tobacco were imported while about 23 tones were exported over the same period with 8,500 million cigarettes imported. In 1995 alone, about 10,259 million sticks of cigarette were consumed in the country[5]. Presently, there are about two cigarette manufacturers in the country and both are affiliated to tobacco multinationals. On the average, about 300 cigarettes are smoked in Nigeria annually per adult (Table 1) and the smokers cut across the different age pattern and groups. Since the literates smoke more than

Corresponding Author: Jacob Ademola Sonibare, Environmental Engineering Research Laboratory, Department of Chemical Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria
Tel: +234-08033837896   E-mail: asonibar@oauife.edu.ng

Table 1: Tobacco consumption pattern in Nigeria

Annual consumption of manufactured cigarette in Nigeria

Period	Average per adult (Age 15[+])
1970-1972	290
1980-1982	350
1990-1992	370

Average cigarette consumption by adult in Nigeria

Adult age group	% Consumption
20-29	7.7
30-39	13.9
40-49	13.1
50 and above	12.3

Average cigarette consumption by different age group in Nigeria

Age group	% Consumption
Total adult smokers	8.6
Total young smokers	18.1
Total young female smokers	16.0
Total young male smokers	16.0

Tobacco consumption in Nigeria according to literacy level

Class	% Consumption
Without education	10.3
Primary education	14.7
Post primary education	10.5
Higher education	10.8

Source: www.cdc.gov/tobacco/who/nigeria.htm

illiterates and with a confirmation that tobacco use among the children and adolescents is increasing with the average age of imitating smoking declining[6], a scientific study of this nature could be used in informing smokers in Nigeria about the danger inherent in smoking and cigarette smoking in the country could be put to a check. WHO[7] even pointed out that children should be provided with information about tobacco and the tobacco industry. Based on current smoking trends, tobacco will soon become the leading cause of death worldwide, causing more deaths than HIV, tuberculosis, maternal mortality, automobile accidents, homicide and suicide combined[8]. At times, it is only the smokers that feel the negative impact of cigarette smoking but it also affects the health of those around them[9]. Except these smokers are enlightened, it may be difficult to discourage them even when they have strong desire to do so[10].

Consideration of indoor air quality is important as lifestyle diaries indicated that up to 85% of time can be spent indoor[11]. Jenkins *et al.*[12] earlier confirmed that Californians spend on average 87% of their time indoors, 7% in enclosed trains and only 6% outdoors. Nigerians experience in indoor lifestyle may not be too different from this. Indoor combustion aerosols from environmental tobacco smoke can typically double particle exposure indoor as particulates can originate from homes in which smokers are present[13]. Guerin *et al.*[14] earlier confirmed that indoor combustion such as cigarette smoke can be predominant source of aerosol.

Tobacco smoking over several decades is one cause of cancer in the lung, oral cavity, pharynx, esophagus, pancreas, bladder and possibly in kidney and liver. Smoking is probably the largest single preventable cause of ill health in the world today. Recent estimates on the effect of passive smoking or lung cancer suggest that 20-30% of non-smoking lung cancer is derived from environmental tobacco through smoke exposure. As a result of research, many health agencies throughout the world have issued warnings to the public that smoking is dangerous to health. Evidence shows that pregnant women who smoke may cause health problems to their unborn babies. According to this evidence, smoking during pregnancy retards fetal growth and development as well as increasing the likelihood of respiratory problems during childhood[15]. Other adverse health effects associated with indoor air pollutants are from cigarette smoking. Many studies have shown a correlation between particulate pollution and several health indicators[16]. Some of these indoor pollutants from cigarette smoking are in form of particulates[17] and there is a need for a good knowledge of their physical and chemical properties for adequate air quality regulations[18]. A major pathway for these particulates to human is vial inhalation and respiratory system has been identified as their major point of attraction. Salma *et al.*[19] reported the distribution pattern of these particulates in the respiratory system under sitting breathing condition using a stoichiostic lung deposition model earlier developed by Wallace *et al.*[20] to calculate the deposition of ambient aerosols in the human respiratory system for human health implication prediction.

Chemical composition of particulates varies and at times this might influence the possible impact on air quality. Also, toxicity varies according to composition[21]. Some Five trace elements (Zn, Pb, Cu, Cd and Ni) in Six different brands of cigarette commonly consumed in Nigeria were investigated in this study. This is to determine the potential harm they constitute to the environment. These metals are part of the over 4,000 chemical compounds identified in tobacco (including 43 known carcinogens) and 500 in smoke[22] Bates *et al.*[23] reported that there are 600 tobacco additives allowed in the cigarettes in the UK while Manus[24] claimed that about 1400 additives could be added and many of them contain trace elements.

Some of the metals are essential to maintain life activities especially cellular actions, body metabolism as there are requires in trace quantity by some body enzymes (e.g. Zinc, Copper, Cadmium, etc.) but may be toxic when it's concentration in the human and animal bodies exceed certain concentration while some are non-essential. They are highly toxic even in small concentration. Human

exposure to these heavy metals occurs mainly through two sources in the non-smoking generation. The first is the oral route by water and food ingestion. The concentration absorbed by this route into the body depends on protein ingestion and presence of some vitamins such as vitamin D. Also, some that are related to the concentration of other essential metals in the body include Zn, Se and Ca with which they compete[25]. The second source is by inhalation. The amount of inhaled metals depends on the concentration of the metals in inhaled air, the retention of particles in the lungs and from the chemical compound inhaled, the physiological status of respiratory system and in the case of smokers the strength of the smoking habit and the concentration of these metals in the cigarette. Most crop species tends to accumulate these metals at high concentration in the root tissue, followed by leaves, then by seeds or storage organs. In contrast, some species of plants such as lettuce (*Latus sativa* L.) cabbage (*Brassica oleracca* L.) and tobacco (*Nicotiana tabacum* L.) will accumulate high concentrations of some metal, most especially Cadmium, in leaf tissue rather that in roots[26]. The leaf is the actual portion of these plants that is consumed, thus, heavy metals can move into the human health.

Zn is primarily an outdoor metal whose only known indoor source is cigarette smoking[20, 27]. It is known to exist in very small particles (mostly smaller than 5 µm) thus constituting great health impact. Both epidemiological and mechanistic data are consistent with a facilitative role for Pb in carcinogenesis[28]. That is, it may not be both necessary and sufficient for the induction of cancer, but at a cellular and molecular level, it may permit or enhance carcinogenic events. Chao and Wong[29] and Afroz *et al.*[30] stressed the health impact of Pb. Established health related problems of Cd and Ni motivated Thomaidis *et al.*[31] to characterize them along with other metals in Athens atmosphere. At least twenty metals have been detected in tobacco smoke and these include: chromium, mercury, cadmium, lead, etc. most of these metals are toxic and affects the environment. This work is aimed at determining trace metals (Pb, Zn, Cu, Cd and Ni) in the urine and Saliva samples of cigarette smokers in relation to the cigarette smoked. It is an effort to assess the distribution of these metals in the system of the smokers and non-smokers for prediction of pollution potential of the cigarette commonly consumed in Nigeria on indoor air quality in the country.

MATERIALS AND METHODS

Sample selection and preparation: Packets of the six most commonly consumed cigarette brands in Nigeria were acquired for this study. The cigarettes were divided into two parts; the first, unsmoked, were separated into filters and the tobacco while the other part was given to the smoker and the ash and the smoked filter were collected. Also collected were urine and saliva samples of the smokers and non cigarette smokers.

The solid samples were dried in the oven at a temperature of 80°C for 13 h and later allowed to cool in the vacuum desiccator, they were separately to allow their easy passage through 20-mesh screen.

Sample analysis: The method of Linde *et al.*[32] was used to determine the heavy metal concentrations in the solid sample by digesting in concentrated trioxonitrate (v) acid (HNO₃. The digestions were done in triplicate. Lead (Pb), Zinc (Zn), Copper (Cu), Cadmium (Cd) and Nickel (Ni) concentrations were determined from these samples using Atomic Absorption Spectrophotometer AAS (acetylene air-flame) (Phillip model Nos Pu9100X).

RESULTS AND DISCUSSION

The sampled materials as a whole showed a wide variation with regard to trace elements (Table 2). Change in composition of tar from cigarette is associated with peculiarity of tobacco plant varieties and tobacco processing[1,33]. Since tar is the aggregate of the combustion products of TPM trapped in the filter minus the water and nicotine[7], the observed variation in trace elements concentrations with respect to brands might be connected with peculiarity of cigarette formulation of

Table 2: Trace element concentration of cigarette samples of different brands

| Trace element	Brand 1	Brand 2	Brand 3	Brand 4	Brand 5	Brand 6
Un-smoked butt						
Pb	0.42	0.47	0.68	0.21	0.55	0.63
Zn	0.33	0.29	0.18	0.14	0.25	0.36
Cu	0.62	0.58	0.74	0.41	0.45	0.62
Cd	0.03	0.05	0.01	0.07	0.10	0.08
Ni	0.15	0.12	0.19	0.17	0.25	0.22
Smoked butt						
Pb	0.97	1.13	1.26	0.73	1.42	1.47
Zn	0.61	0.50	0.44	0.32	0.48	0.55
Cu	0.85	1.16	1.12	0.81	0.99	0.64
Cd	0.31	0.26	0.17	0.24	0.40	0.47
Ni	0.31	0.20	0.27	0.22	0.28	0.24
Tobacco						
Pb	1.44	1.07	1.55	0.92	2.07	1.65
Zn	1.10	0.75	0.97	0.57	1.18	1.06
Cu	1.93	1.29	1.81	1.95	1.47	1.99
Cd	1.17	0.68	0.94	1.03	1.08	0.84
Ni	0.39	0.45	0.34	0.33	0.42	0.36
Ash						
Pb	1.86	1.94	1.71	1.55	2.52	2.23
Zn	0.68	0.52	0.83	0.49	0.77	0.59
Cu	1.39	1.06	1.56	1.31	1.22	1.02
Cd	0.45	0.50	0.59	0.80	0.66	0.52
Ni	0.52	0.47	0.38	0.56	0.48	0.45
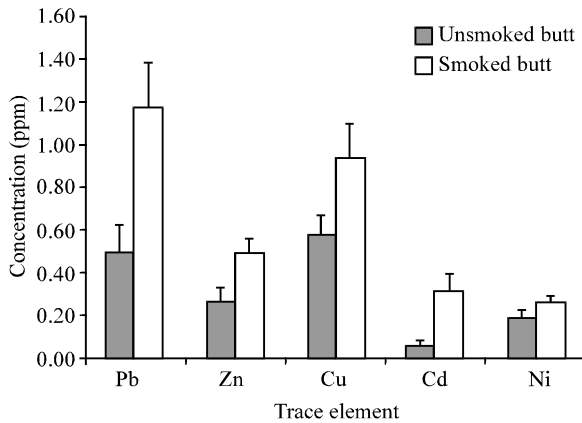
Fig. 1: Composite chart showing trace element content of smoked and unsmoked butt of cigarette

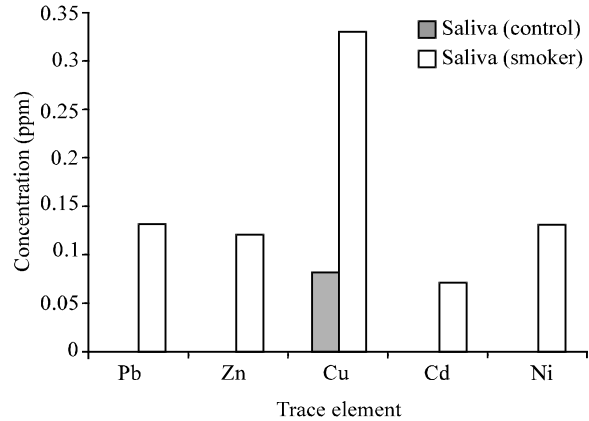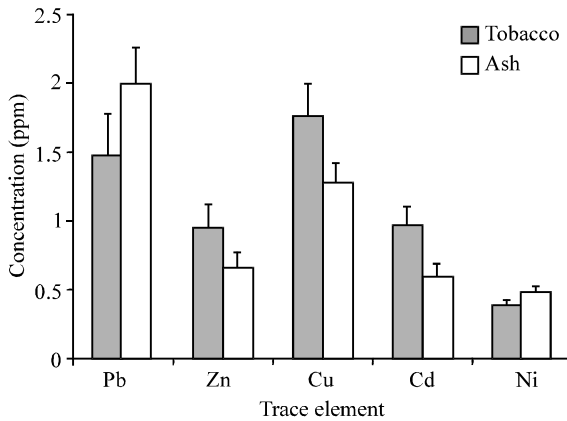Fig. 2: Composite chart showing trace element content of tobacco and ash of cigarette

Fig. 3: Composite chart showing trace elements concentration in urine samples smokers and non-smokers
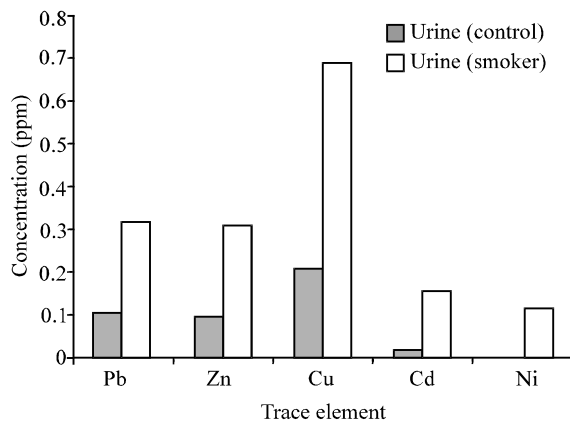

Fig. 4: Composite chart showing trace elements concentration saliva samples of smokers and non-smokers

brand, tobacco varieties and the tobacco processing methods used for each.

For the five trace elements studied, concentrations in unsmoked butts were higher than that of smoked butts, (Fig. 1) for the same cigarette band. In smoked butt Pb level was about 2.5 folds of the concentration in unsmoked butt while Zn and Cu in smoked butt are about 2 folds of the measured levels in unsmoked butt. Also, Ni concentration in smoked butt was about 1.2 folds of unsmoked butt concentration while Cd concentration measured was about 9 folds of that in unsmoked butt. Higher concentrations of trace elements in smoked butt than unsmoked butt could be due to two reasons. First, during cigarette smoking, the combustion process may burn off/volatilize the other components present with the trace element in the unsmoked butt thus resulting in increased relative abundance of the available trace elements. Secondly, possible leakage of trace elements from the tobacco portion of the cigarette to the smoked butt (due to concentration gradients). The higher concentrations of trace elements found in the unsmoked butt than the later (Table 2) is another possible reason.

Both Pb and Ni gave a similar trend of concentration increases from measured level in tobacco to a higher level in ash and the destruction of other tobacco components in combustion as earlier mentioned above could be a strong reason for this. However, a different trend is observed in Zn, Cu and Cd. Their concentrations in tobacco were higher than those in the ash (Fig. 2). During combustion activity which results in ash formation some of these elements could have been produced in free form due to the breaking down of their compounds. This could be a reason shown for the different trend shown by these elements.

Table 3: Toxicity potential

Trace element	Average concentration (mg gᴳ¹)		Threshold limit value (TLV)¹, mg mᴳ³	Toxicity Potential²	
	Tobacco	Ash		Tobacco	Ash
Pb	1.45	1.97	0.2	7.3	9.9
Zn	0.94	0.57	1.0	0.9	0.6
Cu	1.74	1.26	0.1	17.4	12.6
Cd	0.96	0.59	0.2	4.8	2.9
Ni	0.38	0.48	1.0	0.4	0.5

[1]source: Cheremisinoff and Young (1975)
[2]source: calculated by the authors as ratio of TLV to Measured Concentration

Pb, Zn, Cu and Cd were detected in urine samples of both cigarette smokers and non-smokerǁs but with smokerǁs concentrations higher (Fig. 3) while Ni was not detected from the non-smokers samples. The ratios of detected concentrations in non-smokers urine samples to smokerǁs urine are approximately 4 for all the trace elements detected but in saliva, only Cu was detected in non-smokers' samples (Fig. 4) with the other four trace elements (Pb, Zn, Cd and Ni) being below the detectable limit. Strong correlations of 0.86 and 0.65 (Fig. 5 and 6), respectively found between trace element concentrations in the tobacco and smokerǁs saliva on one hand and between tobacco and smokers' urine on the other hand is an indicator that cigarettes could be a major contributor to these trace elements concentrations in both smokers' saliva and urine. This has many implications on indoor air quality.

Due to differences in ventilation levels between indoor and outdoor environments[34], air pollutants concentrations that could be of great risk are of different levels on both sides. Since outdoor ventilation is usually higher than indoor[35], for every smoke from cigarette smoked indoor in Nigeria, there is a great risk of indoor air contamination by the five trace elements detected in the six common Nigeria cigarette brands. Toxicity potential of these trace elements which is an indicator of human exposure implication[36] is very high for Pb, Cu, and Cd (Table 3) and this means that staying indoor with smokers of these cigarette brands could expose non-smokers to a great risk if these elements could find their ways into the air at the level in which they were being detected both in the tobacco and ash samples.

Smoke from the cigarette brands or their ash and tobacco particulates have two possible ways through which they can contaminate the environment. Smoke may be in form of mainstream smoke drawn through the tobacco, taken in and exhaled by the smokers and sidestream smoke which is emitted by the smoldering cigarette between puffs. Over 4000 compounds have been identified in ETS[37] and the detected trace elements in the six brands could be part of these. In addition to the smokers who could be directly affected by these detected
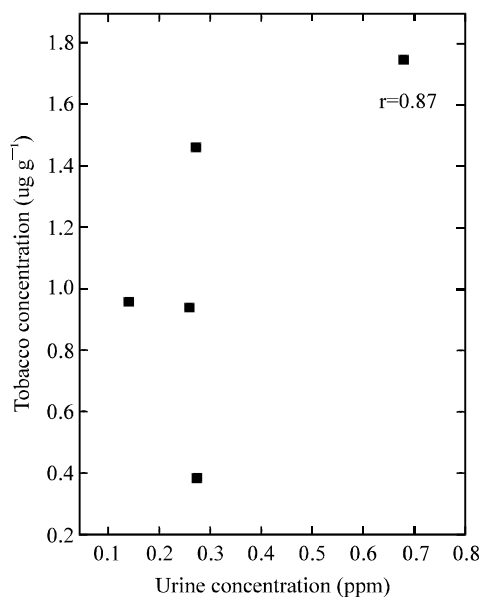

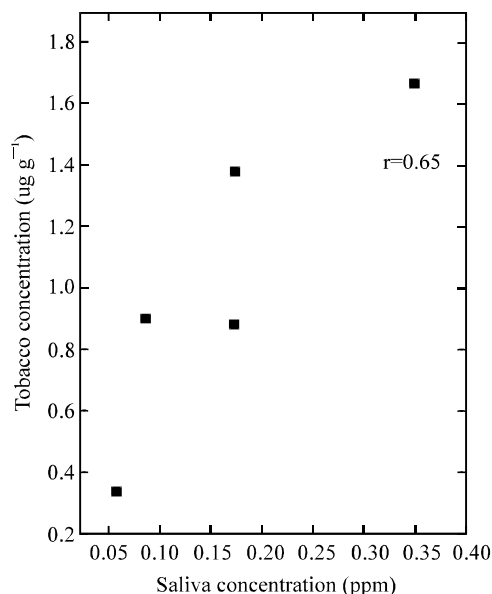Fig. 5: Correlation coefficient tobacco concentration vs. urine concentration

Fig. 6: Correlation coefficient tobacco concentration vs. saliva concentration

trace elements through the smoke are the non-smokers[38,39] and this calls for more efforts at preserving the indoor air quality not only in public places but also in private buildings. Proper education could assist in this area. Apart from smoke which may contain particulates[40], dust re-suspension of these produced ash and tobacco particles from the unsmoked cigarette could be other ways for indoor air contamination of the trace elements via

particulates. Inhalation of such particulates could be of problem to human health. As earlier mentioned, non-smokerIIs are also at a great risk if staying indoor where cigarette smoking takes place. During indoor cleaning exercise, floor sweeping, carpet dusting and allied activities could instigate particulates re-suspension thus exposing all staying in such an environment to a great danger of detected trace elements inhalation. The adverse effects of these elements on man calls for more attention.

In conclusion, the study revealed that continuous consumption of cigarette could cause indoor air quality contamination thus increasing trace element level in human body beyond acceptable limits. This could lead into hazardous situation. Effort should be made by the government at discouraging continual consumption of these cigarettes. A good starting point could be for the nation to ratify the framework convention for tobacco control (FCTC) adopted during the 56th World Health Assembly[41]. This would be another measure to reduce considerably the tobacco epidemic that often results from environmental contamination of these detected trace elements.

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