

Heavy Metal Content of Different Brands of Cigarettes Commonly Smoked in Nigeria and its Toxicological Implications.

G.G. Yebpella, M.Sc.¹; G.A. Shallangwa, M.Sc.²; C. Hammuel, B.Tech.¹;
A. Magomya, M.Sc.¹; M.O.A. Oladipo, Ph.D.³; A.N. Nok, Ph.D.⁴; and J.J. Bonire, Ph.D.²

¹National Research Institute for Chemical technology, Zaria, Nigeria.

²Department of Chemistry, Ahmadu Bello University, Samaru, Zaria, Nigeria.

³Centre for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria.

⁴Department of Biochemistry, Ahmadu Bello University, Samaru, Zaria, Nigeria.

E-mail: gashallangwa@gmail.com*

Telephone: +2348023902967

ABSTRACT

Increases in tobacco smoking have been associated with health implications, hence the need for research into the heavy metal content of tobacco. In this study, 14 brands of cigarettes commonly smoked in Nigeria were investigated. Samples collected were analyzed for heavy metal concentrations using an Atomic Absorption Spectrophotometer. The mean levels of the metals were as follow: $1.22 \pm 0.44 \mu\text{g g}^{-1}$ for Ni; $1.43 \pm 0.47 \mu\text{g g}^{-1}$ for Co; $5.98 \pm 3.07 \mu\text{g g}^{-1}$ for Cu; $24.59 \pm 6.91 \mu\text{g g}^{-1}$ for Zn; $0.74 \pm 0.19 \mu\text{g g}^{-1}$ for Cd; and $10.8 \pm 3.30 \mu\text{g g}^{-1}$ for Pb. While the concentration of metals delivered into smoke was as follow: $0.69 \mu\text{g g}^{-1}$ for Cd; $1.35 \mu\text{g g}^{-1}$ for Co; $6.17 \mu\text{g g}^{-1}$ for Cu; $21.67 \mu\text{g g}^{-1}$ for Zn; $10.08 \mu\text{g g}^{-1}$ for Pb; and $1.33 \mu\text{g g}^{-1}$ for Ni. The results of wet digestion, ash sample studied, and metals levels estimated in smoke showed that when the cigarettes are burned during the process of smoking, metals are retained in the ash with about 70% transferred to the smoke. The metals, distributed in the mainstream smoke, though present in lower concentrations than inside stream smoke, are responsible for the health anomaly in active smokers while those in the side stream smoke are responsible for some health effect in passive smokers.

(Keywords: heavy metals, cigarette smoke, tobacco, Nigeria, toxic effects)

INTRODUCTION

Tobacco cigarettes are widely used throughout the world by men and women; children and

adults. A great number of people have become victims of Environmental Tobacco Smoke (ETS) as they participate passively. The presence of additive compounds like nicotine (delivered to users in different proportions by the ways they are used) is the main reason for cigarette habituation. Other factors that have impact on cigarette smoking habits include mass production, social acceptance, availability, relative cheapness, and its light weight.

The growing of tobacco itself calls for the use of certain chemicals such as fertilizers (Phosphate fertilizers recognized as source of radioactive metals, Polonium-210 and Iron-210) (Winters and Franza, 1982) and pesticides to boost yield and prevent cured leaves from being destroyed by insects (Darrel and Donald, 1980). Metals are also known to be absorbed from the soil and concentrated primarily in the leaves (Myer 1990). The sticky nature of the leaves tends to retain particulates of metals rich surface dust throughout the manufacturing processes. There are still considerable side effects from chronic lead exposures. Lead is a typical cumulative poison. It has a comparative high affinity for proteins. The lead consumed bonds with hemoglobin (red blood pigment) and the plasma protein of the blood. This leads to inhibition of the synthesis of the red blood cells and of the vital transport of oxygen. If the bonding capacity is exceeded, lead is passed into the bone marrow, liver and kidney.

Hausssler *et al.* (1983) suggested that higher levels of cadmium in the blood and urine of exposed workers could arise both from work place contamination of cigarettes and transfer as fumes during smoking.

Tobacco plants contain nickel and several other toxic metals most probably absorbed from the soil, fertilizing products, or from pesticides (Wynder and Hoffmann, 1967). Sunderman and Sundermann (1961) indicated that nickel in a burning cigarette might arise from the volatile, gaseous compounds. Nickel tetracarbonyl is carcinogenic at very low doses. Kreyberg (1978) concluded that tobacco smoking and nickel exposure caused an additive effect for developing lung cancer in workers at a Norwegian nickel refinery.

In many countries, cigarette smoking has been identified as a major, serious health issue and contributor to morality and morbidity of both smokers and passive smokers. Some surveys clarified that the contents of certain chemicals especially cadmium in fats (Mussalo-Rauhamaan *et al.*, 1986), blood (El-Agha and Gokmen 2002; Shahan *et al.*, 1996), and livers (Iwoa *et al.*, 1997) of tobacco smokers are much higher than those of non-smokers.

This work therefore, was initiated to determine some selected heavy metals contents in cigarettes commonly smoked in Nigeria and also to give toxicological implications of high concentrations of these metals.

MATERIALS AND METHODS

Sample Collection

Fourteen different brands of cigarettes were purchased from the Zaria market. Composite samples of each brand were made by removing the papers and filters of five cigarettes taken randomly from a pack of 20 cigarettes and five

cigarettes from each pack of the same brand with different batch numbers were mixed together.

Digestion Method

Two oxidation procedures were considered to bring the solid sample to liquid form which can be measured by Atomic Absorption Spectrometry techniques. The mean weight of each cigarette brand was determined by weighing 5 sticks of each brand before and after removing the paper wrappers. The samples were dried in an oven at 90°C for 1hr and allowed to cool in desiccators. Five grams of each cigarette sample were ashed at 500°C in a muffle furnace. One gram of each of ash and row cigarettes were differently treated with a mixture of concentrated HNO₃ and HCl acid in a ratio of 1:3 and heated to near dryness. The digest was filtered through Whatman filter paper into a volumetric flask and made up to volume with distilled water. This later was analyzed for heavy metals (Cd, Pb, Co, Ni, Cu, and Zn) using an atomic absorption/flame emission spectrophotometer at NAPRI. A standard reference material, cabbage (IAEA-359), was prepared as stated above to validate the method.

RESULTS AND DISCUSSION

Validation of Method and Results

To confirm the reliability of the proposed method for the analysis of Cd, Co, Cu, Pb, Ni, and Zn in cigarettes, a certified reference material, cabbage (IAEA-359), was prepared and analyzed in the same manner the studied samples were analyzed. The result obtained falls within the range given by International Atomic Energy Agency as shown on Table 1.

Table 1: Concentration of Metals in Standard Reference Material.

Element	Analyzed value ($\mu\text{g g}^{-1}$)	Certified value ($\mu\text{g g}^{-1}$)
Cd	0.11	0.12 (0.115-0.125)
Cu	5.60	5.67 (5.49-5.85)
Ni	1.09	1.05 (1.00-1.10)
Zn	38.9	38.6 (37.9-39.3)

Heavy Metal Content in Cigarettes

Figure 1 shows the averaged element concentration in duplicated wet digested samples in $\mu\text{g g}^{-1}$ for each of the 14 cigarettes brands sampled. Cd was observed to be higher in the brand, CSM7 at $1.03\mu\text{g g}^{-1}$ and the lowest level was observed in both CRM1 and CLK10 at $0.44\mu\text{g g}^{-1}$ DW.

Co was observed to be highest in the brand coded CBH2 at $2.03\mu\text{g g}^{-1}$ and the brand CSM7 have the lowest Co concentration of $0.70\mu\text{g g}^{-1}$ DW.

Cu maximum level of $10.00\mu\text{g g}^{-1}$ and minimum level of $1.44\mu\text{g g}^{-1}$ was observed in the brand CLK10 and CEX3, respectively.

The brand CLK10 and CCT8 have the highest and lowest level of Zn detected, respectively.

Pb concentration was observed to be higher in the brand CCT8 at $14.59\mu\text{g g}^{-1}$, while the lowest

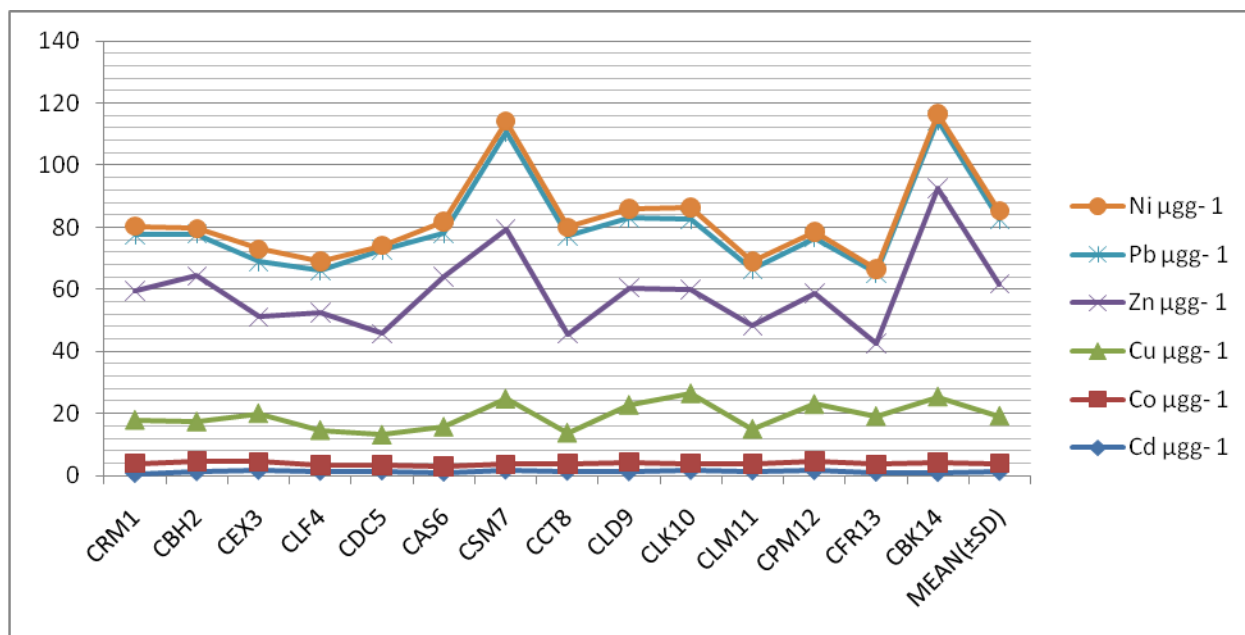
level was observed in the brand CRM1 at $4.01\mu\text{g g}^{-1}$.

Ni detected in the brand CAS6 was at $2.10\mu\text{g g}^{-1}$ and in CBH2 at $0.70\mu\text{g g}^{-1}$, the highest and lowest level of Ni detected for all brands.

The mean concentration of each of these trace metals studied was also determined. Cd, Co, Cu, Zn, Pb, and Ni averaged 0.74 ± 0.19 , 1.43 ± 0.47 , 5.98 ± 3.07 , 24.59 ± 6.91 , 10.82 ± 3.30 , and 1.22 ± 0.44 , respectively. All measurements were made in the unit of measurement $\mu\text{g g}^{-1}$.

Though, the minimum levels of Cd and Pb were observed in one of the high priced cigarettes brands (CRM1) sold in Nigerian market, the claim by some smokers that only the cheap priced cigarettes brands increase their body burden has been disproved by the highest concentration of Cd found in the brand CSM7, the most expensive priced cigarette brand available in our market. From this fact, no brand is considered to be safer than another.

Figure 1: Mean (\pm SD) of Heavy Metals Content ($\mu\text{g g}^{-1}$) of Different Brands of Cigarette Studied.



However, from literature, the amount of trace metals in cigarettes depends several factors including the variety and origin of the plant. Compared to the present study, Jung *et al.* (1998) reported higher concentrations for all metals except for lead (Pb) that was about ten times higher in the present study compared to $1.35\mu\text{g}\text{g}^{-1}$ and $0.74\mu\text{g}\text{g}^{-1}$ obtained for Korean and United Kingdom cigarettes, respectively.

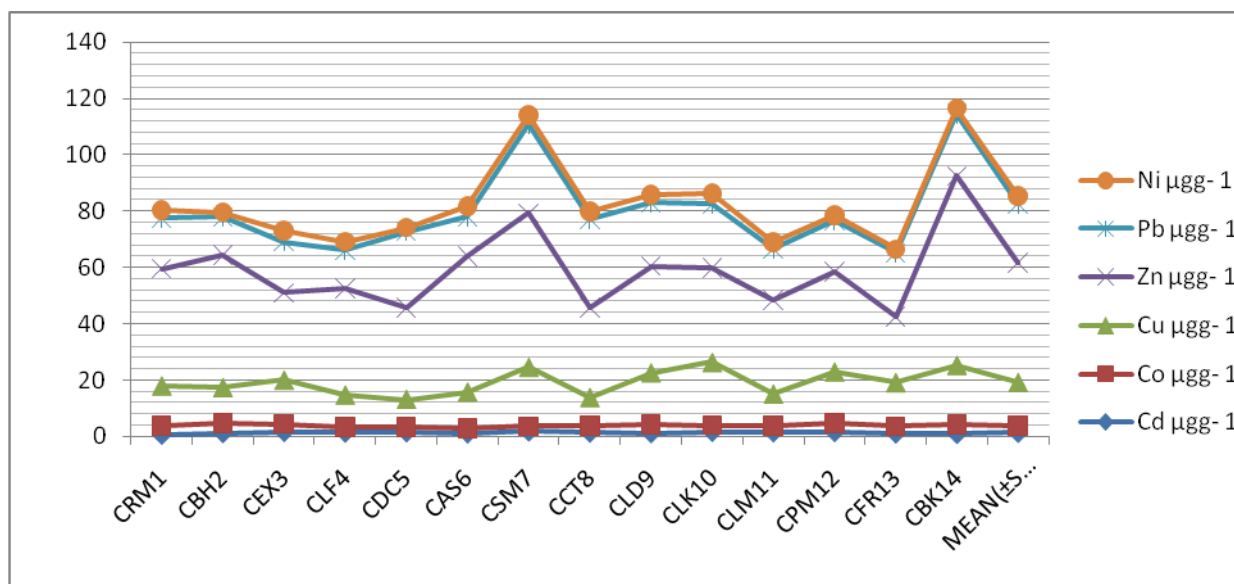
The result obtained for Jordanian cigarettes (Adnan *et al.*, 2003, 2004) does not compare well with the present study, although Pb was reported lower. Also, the work of Nnorom *et al.* (2005); Elinder *et al.* (1983); Nwankwo *et al.* (1977) who individually reported lower levels for Cd in developing countries compared to developed countries corroborate with the present study.

Variation among studies could be due to earlier observations that heavy metal content of cigarettes varied largely with region of production. The concentrations measured in this study were

comparable to those found by Oladipo *et al.* (1993) who carried out a preliminary study of minor and trace metals in Nigerian and compared result with Egyptians cigarettes. The slight incremental difference could result from continual application of chemical fertilizers and pesticides to boost yield by big tobacco companies who cultivate the plant, tobacco in large scale and process it to finished product (cigarette) as earlier suggested by Oladipo *et al.* (1993).

Figure 2 shows the mean \pm standard deviation (S.D) of trace metals levels in ash sample for each brand of cigarette studied in this work. Minimum level of Cd: $0.59\mu\text{g}\text{g}^{-1}$; Co: $1.75\mu\text{g}\text{g}^{-1}$; Cu: $10.00\mu\text{g}\text{g}^{-1}$; Zn: $23.48\mu\text{g}\text{g}^{-1}$; Pb: $13.50\mu\text{g}\text{g}^{-1}$; Ni: $1.39\mu\text{g}\text{g}^{-1}$ were observed in the brands coded: CRM1, CDC5, CCT8, CFR13, CLF4 and CFR13, respectively while maximum level of Cd: $1.75\mu\text{g}\text{g}^{-1}$; Co: $3.50\mu\text{g}\text{g}^{-1}$; Cu: $22.50\mu\text{g}\text{g}^{-1}$; Zn: $67.10\mu\text{g}\text{g}^{-1}$; Pb: $31.58\mu\text{g}\text{g}^{-1}$; Ni: $3.90\mu\text{g}\text{g}^{-1}$ were observed in the brands coded: CSM7, CBH2, CLK10, CBK14, CSM7, and CLK10, respectively.

Figure 2: Analytical Result of Atomic Absorption Spectrometric Analysis of Fourteen (14) Brands of Ashed Cigarette Samples for Heavy Metals Content.



For all the elements of interest determined in this work, the levels obtained do not differ much between the brands except for Pb and Zn. Lead concentration in the brands CSM7 and CCT8 differs largely; about three times higher than in other brands. Zinc concentration in the brands CLK10, CSM7 and CBK14 is about two to three times higher than in other brands analyzed.

The trace metal content established in the smoke emanating from the burning cigarette (i.e., the total trace metal content obtained through wet digestion minus the trace metal content in the ash) is reported in Figure 3.

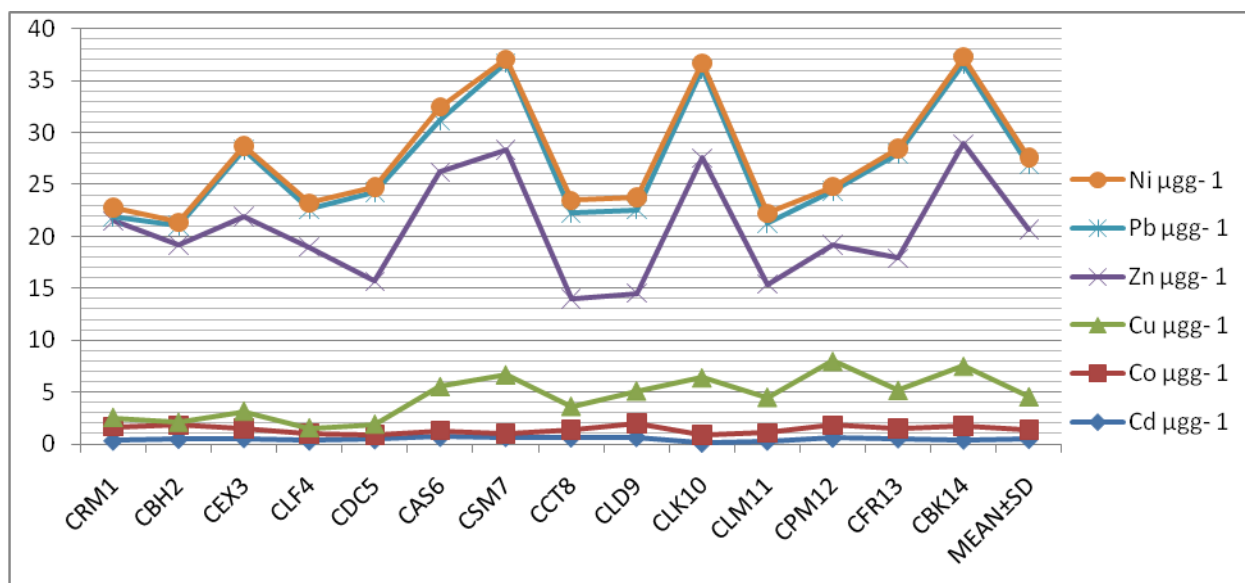
The amount of Cd: $0.69 \mu\text{g g}^{-1}$, Co: $1.35 \mu\text{g g}^{-1}$, Cu: $6.17 \mu\text{g g}^{-1}$, Zn: $21.67 \mu\text{g g}^{-1}$, Pb: $10.08 \mu\text{g g}^{-1}$ and Ni: $1.33 \mu\text{g g}^{-1}$ delivered into the total smoke was observed to be highest in the brands CAS6, CBK14, CPM12, CSM7, CFR13 and CAS6 respectively. Lowest concentration of these metals were observed in the brands CLK10, CSM7, CBH2, CCT8, CRM1, and CEX3 at $0.12 \mu\text{g g}^{-1}$ Cd, $0.34 \mu\text{g g}^{-1}$ Co, $0.26 \mu\text{g g}^{-1}$ Cu, $10.33 \mu\text{g g}^{-1}$ Zn, $0.41 \mu\text{g g}^{-1}$ Pb and $0.33 \mu\text{g g}^{-1}$ Ni respectively. No substantial difference was observed for all elements in the tested brands of cigarettes except for lead which was observed in the brands coded CRM1 and CBH2. Our results

revealed that more than 60% of the analytes determined were transferred into smoke.

Of most importance in this work and for smokers is the amount of metals in the mainstream smoke (i.e., smoke that passes through the filter into the smokers system). Approximately $0.1 \mu\text{g}$ Cd was estimated to be passed into the mainstream smoke, with a daily intake of $2.0 \mu\text{g}$ for a smoker of 20 sticks of cigarettes. The estimated levels especially $2 \mu\text{g}$ for a smoker of 20 sticks of Nigerian cigarettes was higher than the less than $0.1 \mu\text{g}$ Cd and daily intake of $1 \mu\text{g}$ for a smoker of 20 sticks of German filter cigarettes. Another study shows that, this cigarette is known to display higher Cd level and lower Pb level. This corroborates the works of Oladipo et al. (1993) who showed high similarity of German cigarette to Nigerian cigarettes, in most common elements except for Cd and Pb which exhibit higher and lower levels, respectively.

Lead, estimated to range between $0.08 \mu\text{g} - 2.02 \mu\text{g}$, passes into the main stream smoke. There is a relationship between the amount of lead inhaled in Nigerian cigarettes with those inhaled in Korean $0.4 \mu\text{g} - 1.19 \mu\text{g}$ and the United Kingdom $0.22 \mu\text{g} - 0.65 \mu\text{g}$ reported by Jung et al. (1998).

Figure 3: Trace Metal Concentration Estimated for Total Cigarette Smoke.



From the result of our work, an average of 20% of Cu and Zn contained in the tested cigarettes was assumed to be passed into mainstream smoke. Thus based on this, a daily intake of 0.63(0.05-1.23) μg of Cu and 3.22(1.89-4.33) μg Zn was estimated to be passed into mainstream smoke. The quantity of Co and Ni inhalation is estimated to 0.18 μg Co and 0.14 μg Ni and daily intake for a smoker of 20 sticks of cigarettes amount to 3.6 μg and 2.8 μg , respectively.

Nickel (Ni) levels in mainstream smoke range from 0.17-0.27 $\mu\text{g g}^{-1}$ dry weight. These value for some brands exceeded 0.2 $\mu\text{g g}^{-1}$ dry weight (DW) recommended by World Health Organization (WHO). High levels of nickel metal in cigarette smoke may have serious adverse effect on cigarette smokers and passive smoker.

Lead (Pb) levels in mainstream smoke ranged from 0.08-2.02 $\mu\text{g g}^{-1}$ and averaged 1.26 $\mu\text{g g}^{-1}$. The level exceeded 0.00515ppm of National Air Quality Standard. Pb in side stream smoke is about 5 times higher than what is found in the mainstream smoke. Long time accumulation of Pb poison may lead to dead in both active and passive smokers. Copper (Cu) levels in mainstream smoke ranged from 0.05-1.23 $\mu\text{g g}^{-1}$ DW. These values for most brands analyzed exceeded the specific tolerable quantity of daily intake of 0.5mg/kg. Cu content of 0.1-0.2mg/kg body weight has been found to cause digestive disturbance in sensitive consumers of Cu.

CONCLUSION

The concentrations of heavy metal trace elements in cigarette commonly smoked in Nigeria have been determined. The levels of metals especially those with toxicological effects estimated in smoke can cause adverse health effects among smokers. People subjected to Environmental Tobacco Smoke are at higher risk of contracting cigarette smoking health related disease.

The synergistic action of trace metals on certain vital organs in the body is responsible for numbers of complications such as paralysis, strokes, atherosclerosis, and peripheral arterial disease among others.

REFERENCES

1. Darrel, S.M. and Donald, M.E.1980. *Crop Production Principles and Practices*. Macmillan Publishing Co.: New York, NY. 529 – 545.
2. Ebisike, K., Ayejuyo, O.O., Sonibare, J.A., Ogunkole, O.A., and Ojumo, T.V. 2004. "Pollutions Impact of Cigarette Consumption on Indoor Air Quality in Nigeria". *Journal of Applied Sciences*. 4(4): 623-629.
3. El-Agha, O. and Gorkmen, I.G. 2002."Smoking Habits and Cadmium Intake in Turkey". *Biological Trace Element Research*. 88(1):31-43.
4. WHO. 1999. *Environmental Health Criteria 211, Health Effects of Interactions between Tobacco Use and Exposure to Other Agents*. World Health Organization: Geneva, Switzerland.
5. Hausler, E., Lind, B., and Piscator, M. 1983. "Cadmium in Blood and Urine Related to Present and Past Exposure: A Study of Workers in an Alkaline Battery Factory". *British Journal of Industrial Medicine*. 40:420–425.
6. Hoffman, D. and Wynder, E.L. 1967. *Tobacco and Tobacco Smoke*. Academic Press: New York, NY. 730.
7. Jung, M.C., Thomton, I., and Chon, H.T.1998. "Arsenic, Cadmium, Copper, Lead and Zinc Concentration in Cigarette Produced in Korea and the United Kingdom". *Environmental Technology*. 19(2):237-241.
8. Mussalo-Rauhamaa, R.H., Leppanen, A., Salmela, S.S., and Pyssalo, H. 1986. "Cigarette as a Source of Trace Metals, Heavy Metals and Pesticides in Man". *Archives of Environmental Health*. 4:49-55.
9. Myers, J.A.1990. "The Hazards of Smoking". *The Pharmaceutical Journal*. 12:14.
10. Nnorom, I.C., Osibanjo, O., and Oji-Nnorom, C.G. 2005. "Cadmium Determination in Cigarettes Available in Nigeria". *African Journal of Biotechnology*. 40(10):1128 – 1132.
11. Nwanko, J.N., Elinder, C.G., Piscator, M., and Lind, B. 1977. "Cadmium in Zambian Cigarette: An Inter-laboratory Comparison in Analysis". *Zambian Journal of Science and Technology*. 2:1–4.
12. Oladipo, M.O.A., Ajayi, O.O., Elegba, S.O., Alonge, S.O., and Adeleye, S.O. 1993. "The Determination of Minor and Trace Elements in some Cigarettes and Raw Tobacco using Inductively Coupled Plasma Mass Spectrometry

(ICP-MS)". *Journal of Environmental Science and Health. A.* 28:839-857.

13. Scherer, G and Barkemeyer, H. 1983. "Cadmium Concentration in Tobacco and Tobacco Smoking". *Ecotoxicology and Environmental Safety.* 1:71-78.
14. Sunderman, F.W. and Sunderman F.W., Jr. 1961. "Nickel Poisoning: XI. Implications of Nickel as a Pulmonary Carcinogen in Tobacco Smoke". *American Journal of Clinical Pathology.* 35: 203-205.
15. WHO. 1999. *Pretesting Report for Nigeria. Technical Report Submitted to the Social Behaviour Unit.* Global Programme on Tobacco, World Health Organization: Geneva, Switzerland.
16. Winters, T.H. and Franza, J.R. 1982. "Radioactivity in Cigarette Smoke". *New England Journal of Medicine.* 306(6):364-365.

SUGGESTED CITATION

Yebpella, G.G., G.A. Shallangwa, C. Hammuel, A. Magomya, M.O.A. Oladipo, A.N. Nok, and J.J. Bonire. 2011. "Heavy Metal Content of Different Brands of Cigarettes commonly Smoked in Nigeria and its Toxicological Implications". *Pacific Journal of Science and Technology.* 12(1):356-362.



[Pacific Journal of Science and Technology](http://www.akamaiuniversity.us/PJST.htm)