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Heavy Metals Assessment in Some Selected Soft and Alcoholic Drinks in Iwo, Nigeria

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ABSTRACT

This study is aimed at assessing & comparing the levels of some heavy metals in most commonly sold and/or consumed soft and alcoholic drinks in Iwo, Osun State, Nigeria. Three brands each of soft drink (Coke, 7Up & Maltina) and alcoholic drinks (Orijin, Trophy & Goldberg) were bought and analyzed for copper, chromium & lead using Flame Atomic Absorption Spectrophotometric technique. 30 mL of each of the sample was digested, after allowing the sample to stand for 24 hrs for gas evaporation, using dry ashing method; 10 mL of concentrated HNO_3 was added to the ash, filtered and made up to 30 mL mark with 0.1 M HNO_3. The digested samples were analyzed for Cu, Cr & Pb using Buck Scientific Model 210VGP Flame Atomic Absorption Spectrophotometer. Results showed that overall mean levels of Cu were 0.05 ± 0.03 mg/L and 0.09 ± 0.04 mg/L for soft & alcoholic drinks respectively. Chromium was below detection limit of the FAAS and can be inferred to be below tolerance limit set by NIS (0.05mg/L). Lead was detected in both sampled drinks at a concentration ranging from 0.010 - 0.140 mg/L for soft drinks and <DL - 0.240 mg/L for alcoholic drinks which were above 0.01 mg/L set standard for drinking water by NIS. Both Cu & Cr levels in both drinks were below maximum permissible limit, except for lead whose values exceed set limit in some of the drinks (Coke, Maltina, 7Up & Trophy).

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Introduction

Soft drinks and Alcoholic drinks are the most consumed beverages in Nigeria today. Soft and alcoholic drinks exist in various forms and brands and are marketed by different brewery industries within & across the country [1, 2]. These drinks are already consumed on daily bases especially when undergoing tedious activities like hard work and sports. Also, with the relatively affordable prices, they are highly consumed during leisure, relaxation, outings and serve the general public in celebrations and festivals. These celebrations includes: traditional marriages, weddings, birthdays, naming of babies and funerals.

Soft drinks, also known as ready-to-drink beverages are taken in-between meals by some people. In most offices and homes, soft drink is served as lunch along with pastries or biscuit and sometimes bread. The consumption of non-alcoholic beverages in Nigeria was rated at 159.85g/person/day in 2007 [3]. In addition to taste satisfaction, soft drinks contain other constituents such as vitamins, phosphates, acids, antioxidants etc, which are of nutritional and health benefits to the body [4].

On the other hand, alcoholic drink is a beverage containing ethanol. They are legally consumed in most countries and over one hundred countries have laws regulating their productions, sales, & consumption [5].

As a result of the soil, atmosphere, underground and surface water pollution, our foods and beverages are contaminated with heavy metals which have shown to be harmful and toxic to human body [6]. These metals have the potentials of causing acute and chronic toxicity by various modes of action in both children and adults [7, 8]. While some heavy metals act as catalyst in oxidative reactions of biological macro molecules, therefore their intoxication may lead to oxidative tissue damage. Others harmful effects obtainable are genotoxicity, carcinogenicity, chromosomal aberration and mutation [9, 10] Thus, the need for assessment and comparison of levels of Cu, Cr and Pb in commonly sold and consumed soft (Coke, Maltina, and 7Up) and alcoholic (Orijin, Trophy, and Goldberg) drinks in Iwo, Nigeria.

Materials and Methods

Description of Study Area

Iwo is a town in Osun State, Nigeria. It is an agricultural area with distance of about 45 km from Ibadan and Osogbo, the capitals of Oyo and Osun States respectively. It has an area of about 245 km^2 with a geographical coordinates of 7^0 38^1 N and $4^0 11^1$ E, and a population of about 191, 345 making it the most populous Local Government Area in the State of Osun (retrieved from www.osun.gov.ng). The people are primarily Yoruba and of African Traditional Religion. Presently, Iwo is a mixture of three religions with a higher population of Muslims than Christians, and still fewer traditionalists.

Sample Collection and Preservation

Six bottles consisting of three (different) brands of soft drinks and three (different) brands of alcoholic drinks samples, of which are mostly consumed in Iwo, were bought from a retail shop in Odo-ori market, Iwo, in the month of July, 2015. The samples were collected with polythene bag, preserved in it, and kept in the laboratory till analysis.

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Analytical Procedure

The dry ashing method was used in the present study for Atomic Absorption Spectrophotometry [11]. The samples were opened and allowed to rest for 48 hours to allow its gases to evaporate. 30 mL of each of the samples (soft & alcoholic drinks) was measured into 100 mL Pyrex beaker. The samples (both soft & alcoholic drinks) were evaporated on hot plate till dryness. 5 mL of concentrated nitric acid of mass fraction not less than 65%, having a density of approximately 1840 g/L was added, and heating was continued until the volume reduced to about 2 mL. 20 mL of 0.1 M nitric acid was added and filtered into 30 mL volumetric flask. The resultant solution was made up to 30 mL mark with 0.1M nitric acid. Blank solution was treated the same way as the sample. Buck Scientific Model 210VGP Flame Atomic Absorption Spectrophotometer (Buck Scientific, Inc. East Norwalk, USA) was used to read the absorbance values at appropriate wavelength of the interested metals in the sample solution.

The heavy metal in the sample =

$$\frac{\text{Concentration of metals from intstrument X Volume of digest}}{\text{Volume of sample taken for digestion}}$$

mg/L

Results and Discussion

Heavy Metals in Soft Drinks

Table 3.2 shows the levels of copper, chromium and lead in the three different brands of soft drink samples analyzed. The increasing order of Cu levels is 7UP 1 > COK 1 > MAL 1 while that of Pb is COK 1 > MAL 1 > 7UP 1. Analysis was carried out in duplicate for each brand of soft drink samples. Chromium was not detected in all the samples. The mean values determined for copper and lead were 0.05 ± 0.03 mg/L and 0.18 ± 0.25 mg/L respectively (Table 3.4).

[12] reported chromium as 2.3346 mg/L in one of the total of 104 soft drink samples examined in Nigeria. He further reported that the chromium detected in one of the soft drink samples was one of the popular children's drinks (5% of the samples); at a concentration higher than the maximum permissible limit (0.05 mg/L). This is dissimilar to values obtained and may be attributed to different samples used.

The maximum permissible levels set by NIS (Nigerian Industrial Standard) for Cu, Cr, & Pb are 1 mg/L, 0.05 mg/L, 0.01 mg/L respectively, see Table 3.1. The mean levels of copper in soft drink samples were all below/within the safe limit while the mean levels of lead far exceeds the maximum permissible level, therefore, it's above the safe limit. Lead is one out of four metals that have the most damaging effects on human health. Lead toxicity in humans include abnormal size and hemoglobin content of erythrocytes, brain damage, hyper stimulation of erythropoiesis, kidney damage haemosynthesis risk in blood pressure, etc [13].

Heavy Metals in Alcoholic Drinks

Table 3.3 presents the variations in mean concentrations of heavy metals determined from three brands of alcoholic drinks (GDB 1, TPY 1 & ORJ 1) samples analyzed. Each of the brand's samples was also analyzed in duplicate. The mean values determined were 0.040 ± 0.090 mg/L and 0.110 ± 0.240 mg/L for Cu and Pb respectively, see Table 3.3.

In one of the samples analyzed, ORJ 1, Cu was not detected, while its concentrations in GDB 1 and TPY 1 are 0.070 ± 0.014 mg/L and 0.200 ± 0.028 mg/L. Cr was not also detected in any of the alcoholic drink samples analyzed as experienced in soft drink samples. Pb was not detected in two samples (GDB 1 & ORJ 1) analyzed (Table 3.3) while its value in TPY 1 was 0.240 ± 0.113 mg/L; which far exceeds the maximum permissible level set by the NIS (0.010 mg/L).

Table 3.1. Nigerian Standard for Drinking Water Quality.

Parameter	Unit	Maximum Permissible	Health Impact
Aluminum (Al)	mg/L	0.2	Potential Neuro-degenerative disorders
Arsenic (As)	mg/L	0.01	Cancer
Barium	mg/L	0.7	Hypertension
Cadmium (Cd)	mg/L	0.003	Toxic to the Kidney
Chloride (Cl)	mg/L	250	None
Chromium (Cr)	mg/L	0.05	Cancer
Copper (Cu^{2+})	mg/L	1	Gastrointestinal disorder
Magnesium (Mg^{2+})	mg/L	0.20	Consumer acceptability
Manganese (Mn^{2+})	mg/L	0.2	Neurological disorder

SOURCE: Nigerian Industrial Standard (NIS), 2007.

Table 3.2. Heavy metal levels (Total mean ± SD in mg/L) in Soft drinks.

S/N	Sample code	Brand name	Copper	Chromium	Lead
1.	COK 1	Coke	0.010 ± 0.000	<DL	0.010 ± 0.014
2.	MAL 1	Maltina	0.035 ± 0.021	<DL	0.030 ± 0.042
3.	7UP 1	7UP	0.005 ± 0.007	<DL	0.140 ± 0.197

Table 3.3. Heavy metal levels (Total mean ± SD in mg/L) in Alcoholic drinks

S/N	Sample code	Brand name	Copper	Chromium	Lead
1.	GDB 1	Goldberg	0.070 ± 0.014	<DL	<DL
2.	TPY 1	Trophy	0.200 ± 0.028	<DL	0.240 ± 0.113
3.	ORJ 1	Orijin	<DL	<DL	<DL

Comparison of Copper Level in Soft and Alcoholic Drinks

Statistically, the difference between the mean levels of Cu in soft and alcoholic samples was insignificant ($P \leq 0.05$). As presented in Table 3.4, the mean levels of Cu in soft and alcoholic drink samples were 0.050 ± 0.030 mg/L and 0.090 ± 0.040 mg/L respectively. Tables 3.3 and 3.4 show the various levels of the metals in the drinks. TPY 1 has the highest Pb level (0.240 ± 0.113 mg/L), followed by 7UP 1 (0.140 ± 0.197 mg/L) and COK 1 (0.010 ± 0.014 mg/L). The maximum and minimum Cu levels were 0.200 ± 0.028 mg/L and 0.005 ± 0.007 mg/L in alcoholic drink (TPY 1) and soft drink (7UP 1) samples respectively. In other words, alcoholic drinks had the highest Cu level (0.200 ± 0.028 mg/L) than the soft drink samples. This data revealed that the Cu levels found in both soft and alcoholic drink samples were below/within the maximum permissible level. In a similar study, [6] reported Cu level as 0.047 - 1.840 mg/L in a total of 66 fruit juice samples examined in Poland. However, the Cu level in this study was found to be within the range of 0.047 - 1.840 mg/L as reported by [6].

[14] reported Cu level as 0.070 ± 0.009 mg/kg in a total of 104 soft drink samples examined in Turkey. This Cu in soft drink samples were found to be within the Cu level in this

study. [15] reported copper level as 0.83 ± 0.48 mg/L and 0.34 ± 0.05mg/L in fruit juice and

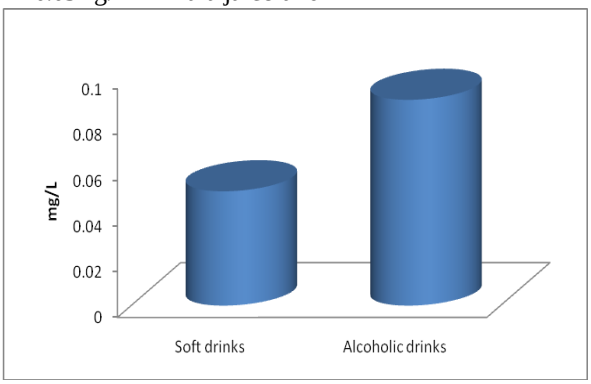

Figure 3.1. Mean concentration of copper in soft and alcoholic drinks.

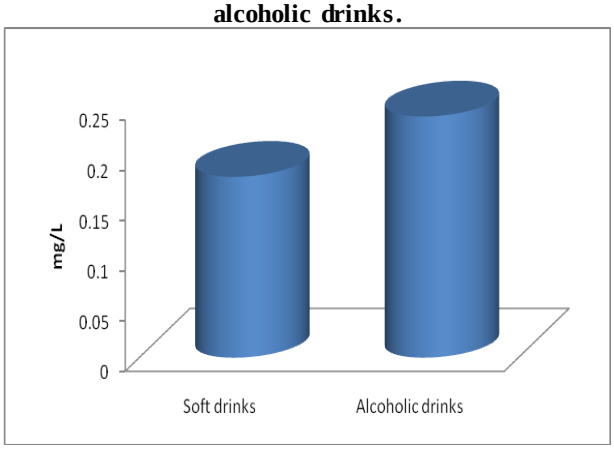

Figure 3.2. Mean concentration of lead in soft and alcoholic drinks.

Table 3.4. Mean Concentration of Heavy Metals in Soft & Alcoholic drinks.

Types of drinks	Copper	Chromium	Lead
Soft drinks	0.050 ± 0.030*	<DL	0.180 ± 0.250^
Alcoholic drinks	0.090 ± 0.040*	<DL	0.240 ± 0.110^

DL = Detection limit. Limit of detection for heavy metal standard are Cu 0.05 mg/L, Cr 0.04 mg/L, Pb 0.08 mg/L.(*Insignificant difference; ^ Insignificant difference at P ≤ 0.05)

Soft drink samples respectively, examined in Ghana and quite higher than Cu in present study. The variations in the levels of Cu observed may be attributed to quality control, purity of manufacturing materials, compliance and non-compliance to regulatory standards by different manufacturing companies.

Although, Cu was present in all the studied drinks, in all other previous studies, the levels were below tolerance limit except for the 66 Polish fruit juice samples (0.047 - 1.840 mg/L). The deficiency of Cu is manifested by impaired haematopoesis, bone metabolism, disorders of the cardiovascular and nervous systems. Toxicity due to excessive intake has been reported to cause liver cirrhosis, dermatitis and neurological disorders [15].

Comparison of Lead Level in Soft and Alcoholic Drinks

Table 3.4 presented the mean levels of lead in the samples analyzed. Statistically, the overall mean values were insignificantly different (P ≤ 0.05). In the soft drink samples, the lead level was 0.18 ± 0.25 mg/L while in alcoholic drink samples; the overall lead level was 0.24 ± 0.11mg/l. The maximum and minimum Pb concentrations were found to be 0.240 - 0.113 mg/L and below detection limit in TPY 1 and ORJ 1/GDB 1 samples respectively. The data showed that the lead level in the soft drink and alcoholic drink samples far exceeds the value set by NIS (i.e. 0.01 mg/L), with exception of ORJ 1 and GDB 1. Research has established that lead can cross the placenta during pregnancy and has being associated with intra uterine foetal death; premature delivery and low birth weight [16]. Lead poisoning, especially among children can lead to damages of the central nervous system, causing mental impairment, affecting oxygen transport in the body and causing digestive problems, long term exposure to lead.

Several studies from different countries had revealed lead level in similar studies' previous reports. [6] reported lead level as 0.020 - 0.46mg/L in a total of 66 fruit juice samples examined in Poland. These lead levels in fruit juice samples were found to be higher than those found in this study. [15] also reported lead levels as 1.59 ± 0.90 mg/L , 7.72 ± 3.12 mg/L respectively in a total of 10 fruit juice and soft drink samples examined in Ghana. The lead level is far from the levels found in this study. [14] reported lead level as 0.029 ± 0.002 mg/kg in a total of 104 soft drink samples examined in Turkey. These lead levels were found to resemble the levels found in this study.

TPY1 (Trophy) was the only alcoholic drink sample that lead was found and at a high level while in soft drink samples, lead was found in all of the three brands/samples. The soft drink sample that had the highest lead level is 7Up (0.140 ± 0.197 mg/L). The maximum concentration of lead detected in alcoholic and soft drinks were 0.24 mg/L and 0.14 mg/L respectively, which were far above the safe limit of 0.01 mg/L recommended by NIS. The high concentration of lead in the samples analyzed could be coming from the metallic container used in preparation of soft and alcoholic drinks and also from the soil where the plants bearing the fruits are grown due to dumping of domestic and industries.

Therefore, it can be concluded that heavy metals are present in the drinks (Cu, Cr & Pb) at levels below & above safe limit. TPY 1 had the highest level of lead and copper, followed by MAL 1 and GDB 1. Lead was detected in 66.7% of the samples and was above safe limit. Consequently, continuous monitoring of manufacturing companies for compliance to set standard, assay of raw materials before processing and effective quality control are recommended to reduce these metals in soft and alcoholic drinks.

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