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Full Length Research Paper

Risk assessment of using coated mobile recharge cards in Nigeria

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The risk assessment of coatings on mobile phone recharge cards on end users has been investigated using mobile phone recharge cards of three major brands (designated as A, B and C) with dominations of ₦200, ₦400 and ₦500 purchased from retail shops in Zaria, Nigeria. To appraise the health risk associated with heavy metal contamination of food by metals from the coatings, Daily Intake of Metals (DIM) and Health Risk Index (HRI) were calculated. The heavy metals was analysed using AAS. Mean concentration of metal ranged between; 12926 to 130, 554 to 294, 13175 to 7025.5, 23691 to 561, 700 to 222.5, 15230 to 5554, 2745.8 to 1429, and 75525 to 11397 $\mu g g^{-1}$ for Mn, Cu, Cr, Zn, Cd, Ni, Pb and Fe respectively. Generally, high concentration of metals was found in Sample C with the exception of Cu. Also, the distribution concentration of the metals were found to be Fe > Cr > Ni > Pb > Zn > Cd > Cu > Mn, followed by Fe > Pb > Ni > Cr > Zn > Cu > Mn > Cd and Fe > Zn > Ni > Cr > Mn > Pb > Cu > Cd for Samples A, B and C respectively in that order of decreasing magnitude. Analysis of difference of means using t-test ($p < 0.05$) showed significant difference between samples for Pb, Cu and Cr among the heavy metals determined. The trend of DIMs for heavy metals in the coatings were in the order of Cd > Al > Zn > Fe > Ni > Cr > Mn > Pb > Cu, with intake from Sample B being greater than Samples C and A for Pb, Cu, Cr, Cd and Ni. Also, the HRI of metals indicated that Pb, Cd and Ni (especially Samples B and C) through adhering 'silver' coatings on mobile recharge cards on nails or under the finger contaminating food were higher than 1, which indicates that users experience relatively high health risk.

Key words: Heavy metals, recharge cards coating, health risk, AAS, Nigeria.

INTRODUCTION

During the last decades, there has been growing interest in determining heavy metal levels in foods and other common food contaminants. With the detection of toxic metals in majority of products sold in third world countries, concern to researchers and health practitioners has tremendously increased. From toxicological and environmental point of view, the determination of toxic metals in metallic products is interesting because by using the products, users could be exposed to these metals through food contamination (Ashraf, 2006).

Contamination of food by heavy metals is a serious hazard depending on the relative level of the metals. Some of these metals such as Cd and Pb, injure the kidneys and cause symptoms of chronic toxicity, including impaired organ function, poor reproductive capacity, hypertension, tumors and hepatic dysfunction (Abou-Arab et al., 1996). On the other hand, Cr, Cu, Fe, Zn and Mn are the major causes of nephritis, anuria and extensive lesions in the kidneys (Chukwujindu et al., 2007).

Metals, a major category of globally-distributed pollutants, are natural elements that have been extracted from the earth and harnessed for human industry and products for millennia. Metals are notable for their wide environmental dispersion from such activity, their

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Table 1. Mean (±SD) characteristics of mobile phones rechargeable cards.

Sample	Length of coating area (cm)	Width of coating area (cm)	Weight of coating (mg)
A	4.1±0.1	0.8±0.0	6.0±0.2
B	3.8±0.0	0.8±0.0	1.0±0.0
C	3.5±0.3	0.8±0.0	0.6±0.0

tendency to accumulate in selected tissues of the human body, and their overall potential to be toxic even at relatively minor levels of exposure. It is essential to characterize the level of heavy metals in mobile phone recharge cards with 'silver' coating since it is not very uncommon to find these coatings deposited under the finger nails. Without proper washing of nails before eating, metal exposure through this route of entry could be a pathway for human intake. The objective of this study is to characterize the levels of metals (Cd, Pb, Cu, Cr, Ni, Co, Fe, Al and Zn) in "silver' coatings of major brands of mobile phone recharge cards sold in Nigeria and subsequently, to determine implications on human health.

MATERIALS AND METHODS

Glass wares, crucibles and plastic containers were washed with liquid soaps, rinsed with distilled water and soaked in 10% HNO_3 for 24 h; cleaned with distilled – deionized water to prevent contamination (Adnan, 2003). Reagents used were of analytical grades. Mobile phone recharge cards of major brands with dominations of ₦200, ₦400 and ₦ 500 were purchased from retail shops in Zaria, Kaduna State in October, 2009. The three major brands of recharge cards were designated as A, B and C. Twenty recharge cards were collected for each brand. During the analysis, the silver coatings were carefully scratched off using a stainless steel scraper into a polythene bag.

The samples were digested with a mixture of HNO_3 and $HClO_4$ for metal determination. 0.05 ± 0.0010 g of the silver coatings sample was placed in a digestion tube and predigested using 10 ml of concentrated HNO_3 at 105°C until the liquor was clear. Then 5 ml of $HClO_4$ was added and digested for 1 h until the liquor became colourless. The samples were evaporated slowly to almost dryness, cooled and dissolved in 5 ml of 1 M HNO_3. The digested samples were filtered through Whatman's No. 1 filter paper and diluted to 50 ml with distilled-deionized water. The sample solutions were analysed with graphite furnace AAS (Shimadzu AA-6800). Metal determinations were done in triplicates for each brand. Blank were also digested in the same manner with the sample. Calibration standards were made by dilution of nitrate salts of all metals determined in 0.5 M of nitric acid supplied by Scharlau Japan. A recovery test of the total analytical procedure was carried out for the metals in selected samples by the Spiking experiment. Acceptable recovery of >90% were obtained for all metals, an indication of good analytical protocol.

Health risk assessment of these metals was done according to Sajjad et al. (2009). Daily intake of metals (DIM) was determined by the following equation:

$$DIM = C_{Metal} \times D_{Intake}/B_{Average\ weight}$$

Where, C_{Metal} = Heavy metal concentration in coatings; D_{Intake} = Intake of metals (approximate 10% of what is scratch is retained under and on the nails); $B_{Average\ weight}$ = Average body mass of an adult 65 kg

Health risk index (HRI) was calculated by using Daily Intake of Metals in food (DIM) and Reference Oral Dose (R_fD). The following formula is used for the calculation of HRI:

$$HRI = DIM/R_fD$$

If the value of HRI is less than 1 (HRI<1), then the health risk exposed to the population is considered acceptable (IRIS, 2003).

RESULTS AND DISCUSSION

The characteristics of the coatings and results of the levels of heavy metals (μgg^{-1}) are presented in Table 1 and Figure 1 respectively. Mean Mn concentration was the highest in Sample C (12926 μgg^{-1}), and the lowest in Sample A (130 μgg^{-1}). Cu concentration was the highest in Sample B (554 μgg^{-1}) and the lowest in Sample A (294 μgg^{-1}).

The highest and the lowest concentrations of Cr were 13175 and 7025.5 μgg^{-1} in Samples C and B, respectively. Zn had the highest concentration (23691 μgg^{-1}) in Sample C and the lowest (561 μgg^{-1}) in Sample A. The highest concentration of Cd (700 μgg^{-1}) was in Sample C, while Sample B had the lowest (222.5 μgg^{-1}). The highest concentration of Ni (15230 μgg^{-1}) was in Sample C and the lowest (5554 μgg^{-1}) in Sample A. Pb concentration was the highest in Sample C (2745.8 μgg^{-1}) and the lowest (1429 μgg^{-1}) in Sample A. The concentration of Fe ranged between 75525 (Sample C) to 11397 μgg^{-1} (Sample A). Generally, high concentration of metals was found in Sample C with the exception of Cu. Also, the distribution concentration of the metals were found to be Fe > Cr > Ni > Pb > Zn > Cd > Cu > Mn for Sample A, Fe > Pb > Ni > Cr > Zn > Cu > Mn > Cd for Sample B and Fe > Zn > Ni > Cr > Mn > Pb > Cu > Cd for Sample C in the order of decreasing magnitude. Analysis of difference of the concentration means using t-test ($p < 0.05$) showed significant differences between Samples for Pb, Cu and Cr among all the heavy metals determined.

To appraise the health risk associated with heavy metal contamination of food by metals from the 'silver' coatings of recharge cards of mobile phones, Daily Intake of Metals (DIM) and health risk Index (HRI) were calculated.

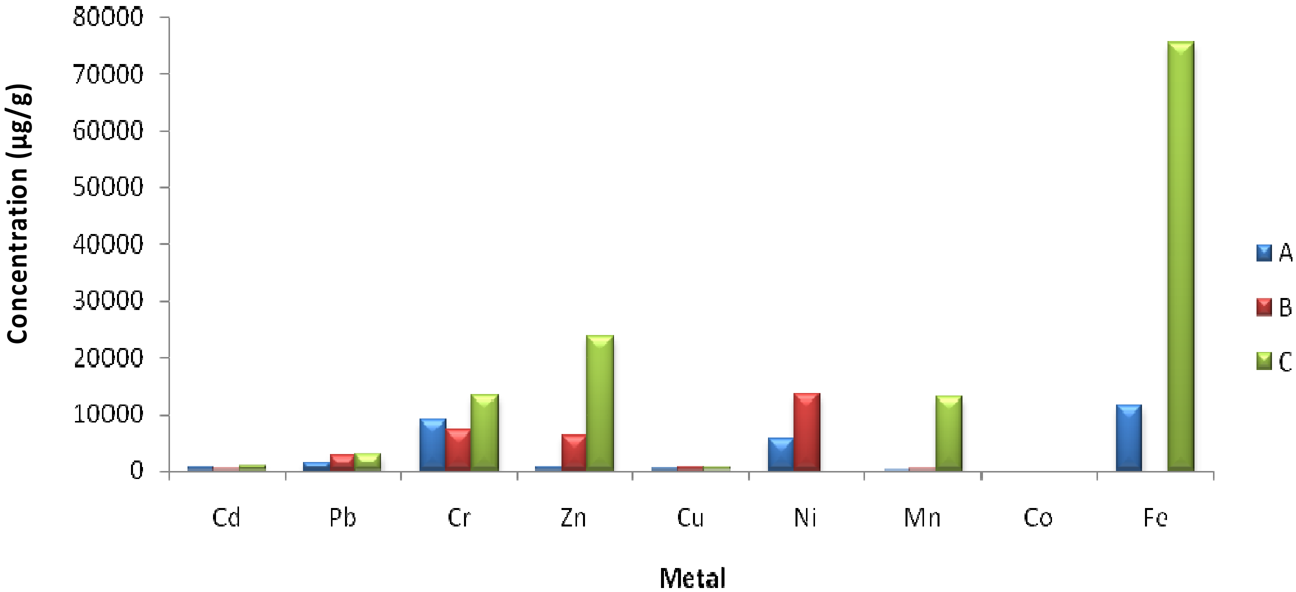

Figure 1. Mean concentration of heavy metal in mobile phones rechargeable cards coatings.

The DIM of heavy metals was estimated based on the average concentration of each heavy metal in each sample as shown in Figure 2. The estimated DIMs of heavy metals (Mn, Pb, Cr, Fe, Al, Ni, Cu, Zn, Pb and Cd) ranged between: 2.43 E-2 to 2.20E-3 µgday^{-1} for Pb, 5.11E-3 to 4.52E-4 µgday^{-1} for Cu, 6.49E-2 to 1.38E-2 µgday^{-1} for Cr, 3.18E-2 to 2.00E-4 µgday^{-1} for Mn, 1.94E-1 to 2.88E-3 µgday^{-1} for Zn, 1.86E-1 to 1.75E-2 µgday^{-1} for Fe, 2.05 to 7.66E-1 µgday^{-1} for Cd, 2.49E-1 to 4.78E-3 µgday^{-1} for Al, and 1.10E-1 to 8.55E-3 for Ni. The trend of DIMs for heavy metals in the coatings were in the order of Cd > Al > Zn > Fe > Ni > Cr > Mn > Pb > Cu, with the intake from Sample B being greater than Samples C and A for Pb, Cu, Cr, Cd and Ni.

The Health Risk Index (HRI) has been recognized as a useful indicator for evaluation of risk associated with the consumption of metals in contaminated food (Sridhara et al., 2008). The health risk assessment in this study was done for some metals (Pb, Cu, Cr, Mn, Zn, Cd and Ni) as shown in Figure 3. The HRIs of Pb, Cd and Ni (especially in Samples B and C) were higher than 1 (HRI > 1), which show that the users of mobile phones using 'silver' coating recharge cards are experiencing relatively high health risk. However, Moriguchi et al. (2004) suggested that the ingested dose of heavy metals is not equal to the absorbed pollutant dose in reality, as a fraction of the ingested heavy metals may be excreted, with the remainder accumulated in body tissues where it can affect human health.

According to Chien et al. (2002) and Sajjad et al. (2009), if the value of HRI is less than 1 (HRI < 1), the health risk to the population is considered acceptable. On the other hand, if the HRI is equal or greater than 1 (HRI ≥ 1) the population is exposed to unacceptable health risk. Based on the results, it shows that the population consuming Sample B and C recharge cards are exposed to high health risks due to Pb, Cd and Ni.

Health implications

The health implications of heavy metals refer to the harmful effects of heavy metals to the body when being consumed above the bio-recommended limits. Cadmium is toxic at extremely low levels; there is no 'safe exposure' for the human body even at minute levels. Long term exposure results in renal dysfunction, characterized by tubular proteinuria. High exposure can lead to obstructive lung disease- and cadmium pneumonitis, resulting from inhaled dusts and fumes. It is characterized by chest pain, cough with foamy and bloody sputum, and death of the lung tissues' lining because of excessive accumulation of watery fluids. Cadmium is also associated with bone defects, viz; osteomalacia, osteoporosis and spontaneous fractures, increased blood pressure and myocardic dysfunctions. Depending on the severity of exposure, the symptoms of effects include nausea, vomiting, abdominal cramps, dyspnea and muscular weakness. Severe exposure may result in pulmonary odema and death. Pulmonary effects (emphysema, bronchiolitis and alveolitis) and renal effects may occur following subchronic inhalation exposure to cadmium and its compounds (McCluggage, 1991; INECAR, 2000; European Union, 2002; Young, 2005).

Lead is the most significant heavy metal toxin and the

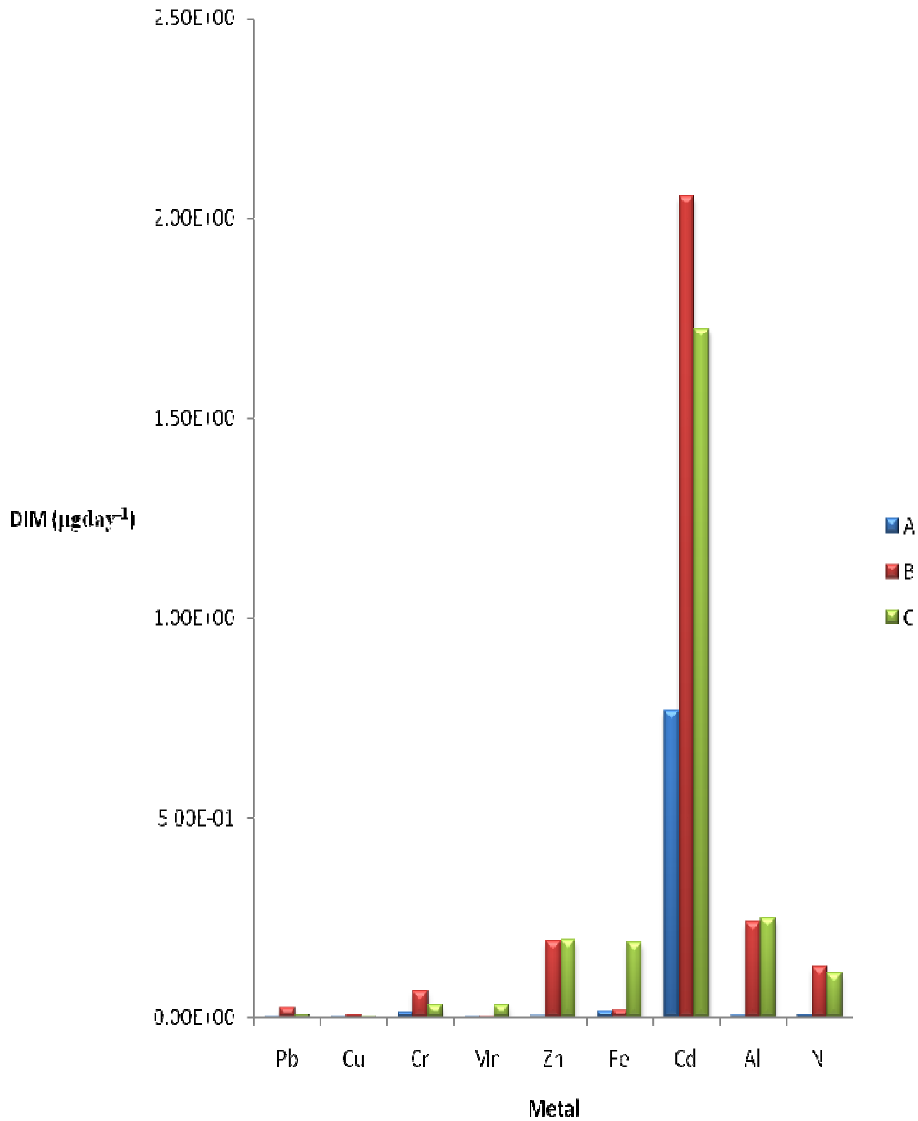

Figure 2. Daily Intake of Metals in recharge cards coatings.

inorganic forms are absorbed through ingestion (food and water) and inhalation (Ferner, 2001). A notably serious effect of lead toxicity is its teratogenic effect. Lead poisoning also causes inhibition of the synthesis of haemoglobin; dysfunctions in the kidneys, joints and reproductive systems- and cardiovascular system as well as acute and chronic damages to the Central Nervous System (CNS) and Peripheral Nervous System (PNS) (Ogwuegbu and Muhanga, 2005). Other effects include damage to the gastrointestinal tract (GIT) and urinary tract resulting in bloody urine, neurological disorder and can cause severe and permanent brain damage. While inorganic forms of lead typically affect the CNS, PNS, GIT and other biosystems, organic forms predominantly affect the CNS (McCluggage, 1991; INECAR, 2000; Ferner, 2001; Lenntech, 2004). Lead affects children by leading to the poor development of the grey matter of the brain, thereby resulting in poor intelligence quotient (IQ) (Udedi, 2003). Its absorption in the body is enhanced by Ca and Zn deficiencies. Acute and chronic effects of lead result in psychosis.

Toxicological implications

The poisoning effects of heavy metals are due to their interference with normal body biochemistry in the normal metabolic processes. When ingested, in the acid medium of the stomach, they are converted to their stable oxidation states (Zn) and combine with the body's biomolecules such as proteins and enzymes to form strong and stable chemical bonds. Figure 4 shows

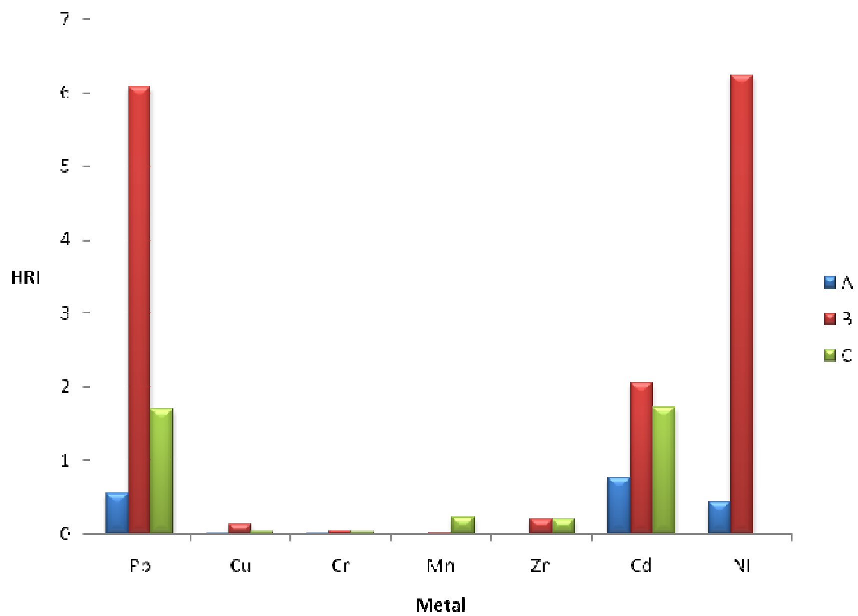

Figure 3. Health Risk Index of heavy metals.

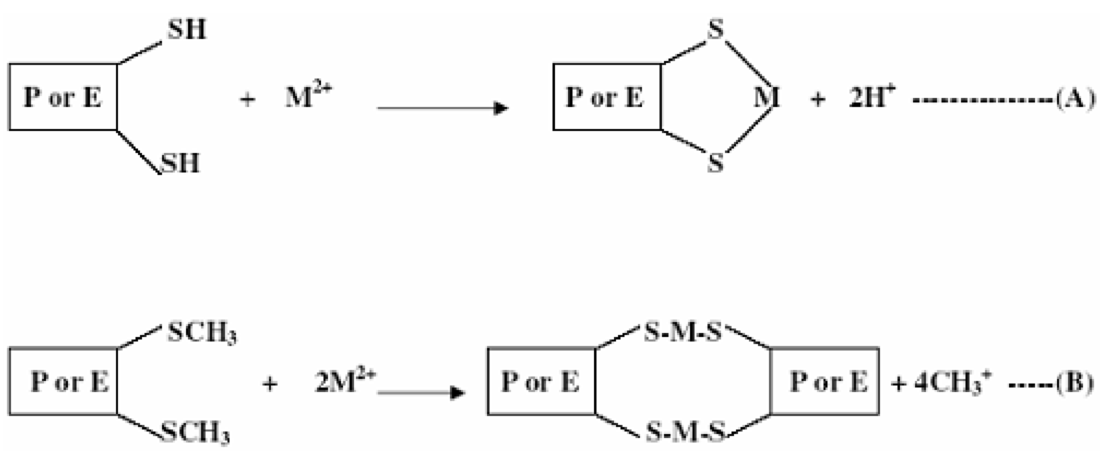

Figure 4. Biochemistry of toxicity of heavy metals (Adopted from Ogwuegbu and Ijioma, 2003). (A) = Intramolecular bonding; (B) = Intermolecular bonding; P = Protein; E = Enzyme; M = Metal The hydrogen atoms or the metal groups in the above case are replaced by the poisoning metal and the enzyme is thus inhibited from functioning, whereas the protein–metal compound acts as a substrate and reacts with a metabolic enzyme.

their reactions during bond formation with the sulphydryl groups (-SH) of cysteine and sulphur atoms of methionine (-SCH) (Ogwuegbu and Ijioma, 2003).

Conclusion

The results obtained from this study generally indicated the presence of heavy metals especially Pb, Cd, Cr and Ni in coatings on mobile phone recharge cards majorly used in Nigeria. The presence of the metals is of greater concern especially due to their health risk compared to other metals. The results of the study also suggested that population using Samples B and C recharge cards are potentially exposed to unacceptable health risks due to Pb, Cd and Ni. In order to avoid food contamination, proper washing of hands after scratching off coatings on recharge cards is a basic but important practice. Apart from that, using the printed numbers to top up the mobile phone account should be encouraged since this does not present metal exposure hazard and is economical.

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