

Research Article

Quantifying the Levels of Niobium, Copper, Arsenic, Tellurium, Antimony and Lead in Selected Toothpaste and Lipsticks Samples

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Abstract

Cosmetics are essential products for many people worldwide because they help enhance a person's appearance and boost attractiveness. However, the only challenge in developing countries is the availability of cosmetics that do not meet quality standards, which can pose health risks to users. Upon this study, lipstick samples were found to have high concentration of heavy metals, which are copper (Cu), Arsenic (As), Tellurium (Te), Niobium (Nb), Antimony (Sb), and Lead (Pb) at 50.0 ppm, 2.0 ppm, 48.0 ppm, 30.0 ppm, 25.0 ppm, and 7.0 ppm respectively. With respect to toothpastes, three metals that were found in significant amounts are Cu at 10.0 ppm, Te at 31.0 ppm and Ta at 12.0 ppm. The level of Antimony (Sb) in lipsticks was found to be higher than the limit set by World Health Organization (WHO). This can lead to problems such as skin disease, hormonal disorders, and even cancer. Due to this situation, there is a need to strengthen regulation and monitoring of cosmetic quality in the market, as well as to educate consumers on the importance of choosing safe products for their health. Additionally, cosmetic manufacturers should adhere to international standards to protect the health of consumers.

Keywords: Lipsticks; Toothpaste; Tellurium; Antimony; Arsenic; Niobium

Introduction

Lipstick is generally made from a blend of waxes, oils, pigments, and emollients [5]. Typical waxes, such as beeswax, carnauba wax, and candelilla wax, give the lipstick its structure and firmness [38]. Oils like castor oil, lanolin, and mineral oil ensure smoothness and even application [14]. Emollients such as shea butter and vitamin E are included to moisturize and protect the lips [40]. Other pigments, which include a range of natural and synthetic dyes, give lipstick its color. Furthermore, lipsticks and toothpaste are cosmetics intended for application in the oral area, including on the mouth parts, specifically on lips and teeth [15]. Toothpaste typically contains a combination of abrasives, fluoride, flavoring agents, and other ingredients that aid in cleaning, polishing, and freshening breath [34]. Although toothpaste is mainly used for oral hygiene, it also improves the appearance of teeth and contributes to a bright, healthy smile. Lipstick is a popular cosmetic product used to improve the color, texture, and overall look of the lips [17]. It plays a key role in facial aesthetics and carries cultural, psychological, and economic importance. Examples of lipsticks are Matte Lipsticks, Satin and Cream Lipsticks, Gloss Lipsticks, and Liquid Lipsticks [33].

Toothpaste is a gel or paste used in combination with a toothbrush to clean and maintain the health of teeth [26]. Its primary functions are to remove plaque, prevent tooth decay, and reduce gum disease [20]. As toothpaste is used by both adults and children. Reports show that children and some adults (pregnant women especially), swallow

a substantial amount of 5 toothpaste in the process of brushing, which could lead to any of the effects associated to the ingestion of these substances [16].

Heavy metals are metallic elements with high atomic weights and densities that are often toxic at relatively low concentrations [2]. They occur naturally in the environment and can also be introduced through industrial processes, agriculture, and pollution [1]. Some heavy metals are essential for biological functions in trace amounts, but excess exposure can lead to serious health problems [21].

The presence of heavy metals in lipsticks and toothpastes is a significant concern due to their potential health risks [9]. Heavy metals found in lipsticks and toothpastes may include lead, cadmium, mercury, and chromium. These metals can be present as contaminants in pigments used for coloring or as impurities in raw materials [23]. Even small amounts of lead can accumulate in the body over time and potentially result in neurological and developmental issues, particularly in children and pregnant women [35]. Exposure to cadmium is associated with kidney damage, bone loss, and cancer [8]. Mercury also can affect the kidneys, nervous system, and immune system, and is particularly harmful when absorbed through the skin or ingested [41].

Zanzibar has emerged as a significant market for cosmetics, with numerous products imported from various countries. The

affordability of these cosmetics has led to widespread usage among individuals, particularly those in the middle and lower socioeconomic groups, often without adequate consideration of the product's quality and safety. This research aimed at assessing the levels of toxic metals present in some lipsticks and toothpastes sold in different stores throughout Zanzibar.

As far as public health is concerned tellurium (Te), is ranked higher in toxicity. However, after surveying the previous literature, it has been found that the data reporting the toxicity of these heavy metals are very scarce. As technology advances, demands for the rare such as element Te and other elements are piling up. Because of its extreme toxicity, Te is known to induce both acute and chronic toxicity in different living organisms. For instance, Te exposure is believed to induce neurotoxicity, demyelination, oxidative stress, and neuronal death [22]. Currently, there is no health-related information for such metals like Niobium, Tantalum and Bismuth, thus their existence needs a comprehensive toxicological essay to discover their health impacts.

Toxicity of Selected Metals

Lead (Pb)

The element lead (Pb) has harmful effects to human health, it can enter into the body of organisms via process like inhalation and ingestion, while to a smaller degree it can enter the body through skin absorption [4]. Medical professionals associate the consumption of lead with delayed onset of puberty in girls, menstrual irregularities, and infertility complications. At any level of exposure lead is considered to detrimental [6,13,18]. Moreover, lead is also considered to be latent killing element to living organisms including human [39].

Cadmium (Cd)

Cadmium is one of the most harmful metals. Thus it is not expected to be used or found in the beautification items because it causes serious damage when applied to the body [37]. Cadmium being extremely toxic can cause kidney damage, and bone deformities to mention but a few of its harmful effects even at small level of exposure [29]. Other health impacts associated with consumption of Cd are such as red blood cell damage and hypertension [7]. Females who use Cd-containing cosmetics daily risk passing it on to their offspring when pregnant or breastfeeding. Human placenta can accumulate a considerable amount of cadmium damaging steroid hormone synthesis and reproductive system [25]. Current researches have linked Cd to such cancer cases like that of prostate, kidney, pancreas and lung [32].

Mercury (Hg)

Mercury (Hg) is considered as the third-most hazardous metal, it has a tendency of being extremely bio accumulative [10]. It can be absorbed through the skin, and easily can reach the bloodstream even in small extents causing depigmentation inside the nucleus [12]. The unrealistic beauty standards can lead to dangerous consequences. The use of lipsticks containing mercury can endanger the circulatory and urinary systems [30]. The WHO recently warned that the presence and consumption of mercury containing cosmetics are potentially lethal as they can lead to leukaemia, kidney cancer and liver damage [11].

Arsenic (As)

The hazardous element arsenic (As) is typically present in cosmetics, and it has negative effects due to its affinity to skin and keratinizing structures, such as hair and nails [34]. Arsenic can be absorbed through skin ingestion, inhalation, or cosmetic use and has been linked to a variety of health problems, including development, liver enlargement, nervous system damage, skin lesions, respiratory issues, skin cancer and even death [37]. Moreover, arsenic is a protoplasmic toxin primarily affecting the sulfhydryl group of cells, causing disruptions in mitosis, cell respiration, and cell enzymes. It also causes malignancy, and hyperkeratosis [36]. The persistent use of arsenic containing cosmetics leads to circulatory complication, neurological damage, and DNA dysfunction. It causes toxicity by blocking the actions of several mitochondrial enzymes, which impairs cellular respiration and oxidative phosphorylation [19].

Methodology

Samples Collection

A total of Eight (8) cosmetics including four (4) lipsticks and four (4) toothpastes purchased at Darajani markets in Zanzibar, all of which were within the expiry dates.

Samples Preparation and Analysis

The samples were prepared under established Standard Operating Procedures (SOPs) and laboratory protocols, adhering strictly to the guidelines outlined in the field sample preparation process. Approximately 5.0 grams of each sample were accurately weighed using a beam balance and placed in sample holders for further analysis. The sample were analyzed using an Energy Dispersive X-Ray Fluorescence (EDXRF) spectrometer (The Rigaku NEX CG model). These fluorescent X-rays are captured in a detector and counted by a multi-channel analyzer. The NEX CG software then calculates the concentration of each element present in the sample.

Data Analysis

The data analysis focuses at assessing the levels of some heavy metals in selected cosmetics. These selected cosmetics consisted of four (4) lipsticks and four (4) toothpastes. The parameters involved in the descriptive analysis of the data are mean, standard deviation, minimum, and maximum values of the metals (Table 1 & Table 2). During sample analysis, seven (07) metals Cu, Cd, Nb, Ta, Hg, Pb, and Bi, and three (3) metalloids (arsenic (As), antimony (Sb), and tellurium (Te)), their levels were assessed in unit of ppm for each sample.

Table 1: Descriptive Statistics of Metals in Lipsticks.

Elements	Minimum (ppm)	Maximum (ppm)	Mean (ppm)	Std. Deviation (ppm)
Cu	9	50	23.25	19.363
As	BDL	2	1.00	1.155
Cd	BDL	BDL	NA	NA
Nb	BDL	30	14.75	17.037
Sb	BDL	25	6.25	12.500
Ta	BDL	BDL	NA	NA
Hg	BDL	BDL	NA	NA
Pb	BDL	7	2.75	3.403
Bi	BDL	BDL	NA	NA
Te	BDL	48	32.75	22.081

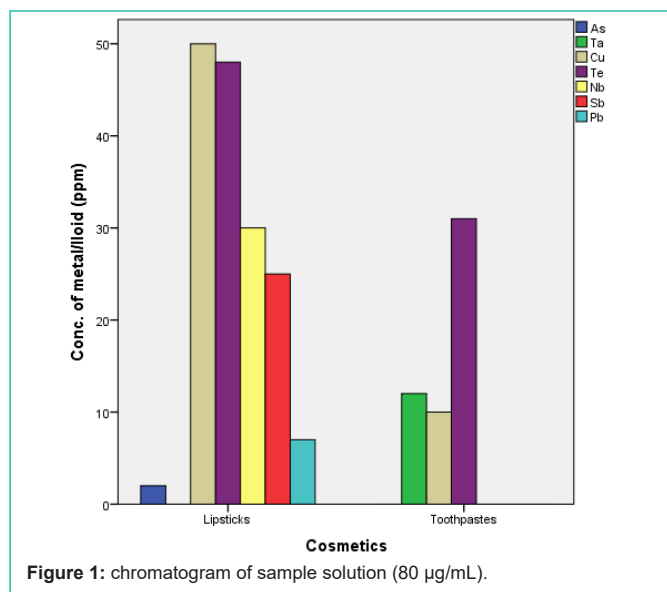


Figure 1: chromatogram of sample solution (80 µg/mL).

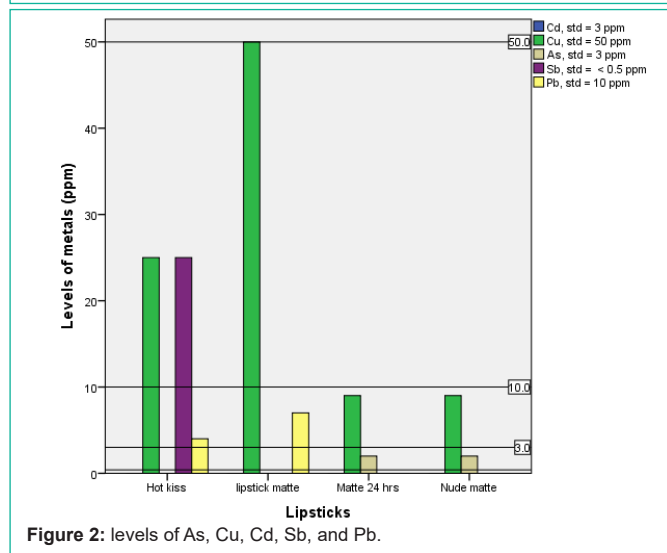


Figure 2: levels of As, Cu, Cd, Sb, and Pb.

General Data Analysis of Metals in Lipsticks and Toothpastes

Lipsticks and Toothpastes were tested for the presence of heavy metals, and the results showed that lipsticks contain a higher level of heavy metals compared to toothpastes. Six metals (As, Cu, Nb, Pb, Sb, and Te) were found in lipsticks accounting for 70 % of all the metals analyzed, while only three metals (Cu, Ta, and Te) were detected in toothpastes which is equivalent to 30 % (Table 3 & Figure 1).

Data Analysis on As, Cu, Cd, Sb, and Pb in Lipsticks

The lipsticks which were included in this study are (Nude matte, Matte 24 Hours, Hot kiss and Lipsticks matte) all imported from China. Antimony (Sb) and Arsenic (As) as metalloids and heavy metals Cu, and Pb were detected in all lipstick's samples, while Cd was not detected (below the detection limit). Cu, Sb, As, and Pb levels were 50.0 ppm, 25.0 ppm, 2.0 ppm, and 7.0 ppm respectively (Figure 2). The Antimony level exceeds the maximum amount suggested by WHO and USFDA, which is (<0.5 ppm). The levels of these metals, were in the following trend: Cu > Sb > Pb > As.

Table 2: Descriptive Statistics on Metals in Toothpastes.

Elements	Minimum (ppm)	Maximum (ppm)	Mean (ppm)	Std. Deviation (ppm)
Cu	3	10	6.25	2.986
As	BDL	BDL	NA	NA
Nb	BDL	BDL	NA	NA
Cd	BDL	BDL	NA	NA
Sb	BDL	BDL	NA	NA
Te	BDL	31	7.75	15.500
Ta	BDL	12	3.00	6.000
Hg	BDL	BDL	NA	NA
Pb	BDL	BDL	NA	NA
Bi	BDL	BDL	NA	NA

Table 3: Occurrence of Metals in Lipsticks and Toothpastes.

Cosmetics	Trend of Metals	Metals Below Detection Limit
Lipsticks	Cu > Te > Nb > Sb > Pb > As	Cd, Ta, Hg, and Bi
Toothpastes	Te > Ta > Cu	As, Nb, Cd, Sb, Hg, Pb, and Bi

Data Analysis on Bi, Hg, Nb, Ta, and Te in Lipsticks

Another metals detected in lipstick samples were Nb, and Te, at 30.0 ppm and 48.0 ppm respectively. Bi, Hg, and Ta were below detection limits (Figure 3).

Data Analysis of Metals in Toothpaste Samples

In toothpaste samples, seven (07) metals which are: Cu, Cd, Nb, Ta, Hg, Pb, and Bi, and three (3) metalloids (arsenic (As), antimony (Sb), and tellurium (Te), their levels were assessed in each sample in unit of ppm. But in toothpaste samples only one (1) metalloid (Te), and two (2) metals (Ta and Cu) were detected. Cd, As, Sb, Nb, Hg, Bi, and Pb were below detection limit.

Assessment of Cu, Ta and Te.

The traces of Cu, Ta, and Te were detected in toothpaste samples at levels of 10.0 ppm, 12.0 ppm, and 31.0 ppm respectively (Figure 4).

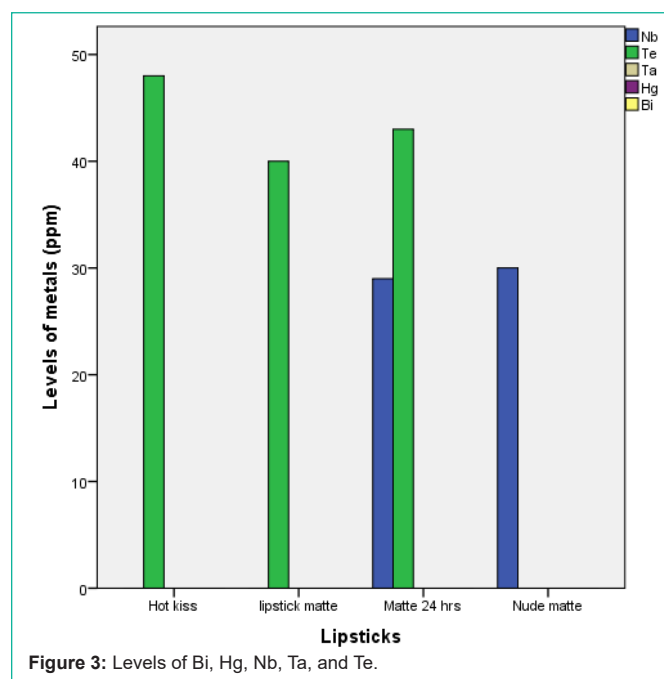


Figure 3: Levels of Bi, Hg, Nb, Ta, and Te.

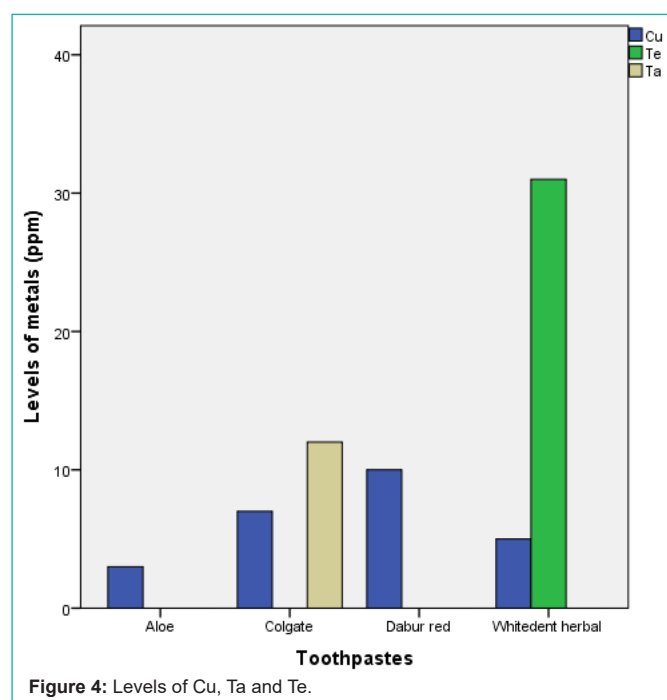


Figure 4: Levels of Cu, Ta and Te.

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