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ORIGINAL ARTICLE

Health Risk of Natural Radioactivity and Trace Metals in Shaving Powder

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KEYWORDS

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ABSTRACT: Natural radioactivity and trace elements content of two brands of shaving power that are commonly used by men were determined, in order to evaluate their radiological effect and health risk. The activity concentrations of the radionuclides were measured using gamma spectrometer equipped with calibrated NaI(Tl) detector system while the trace metals were measured using atomic absorption spectrophotometric (AAS) and energy dispersive x-ray fluorescence (ED-XRF) techniques. The averaged activity concentrations of ^{238}U, ^{232}Th and ^{40}K were 2445.97 ± 9.29 Bq kg^{-1}, 315.16 ± 17.72 Bq kg^{-1} and 50.45 ± 1.79 Bq kg^{-1} for ^{40}K, ^{232}Th and ^{238}U, respectively. The equivalent dose had a mean value of 2.94 mSv year^{-1}. The results of the trace elements analysis from both AAS and ED-XRF showed that iron had the highest concentration while selenium had the least concentration. ED-XRF showed a better recovery of the trace elements than AAS. The levels of the radionuclides identified were above the normal background for humans and the average concentrations of most of the trace metals were also above the permissible exposure limits, which can constitute health hazard to users of the shaving power.

INTRODUCTION

There are a number of traditional techniques of removing hair from human body, which include using depilatory creams, waxing, electrolysis, tweezing, shaving with razor, and light technology with intense pulsed light systems and lasers.The light technology can help in long term removal of air [1]. Cosmetic preparation of shaving power is also common in facial hair removal. Of recent, there has been more predominance use of it than razor blade for the removal of facial hair in order to stop razor bumps. Shaving powder of various strengths are now available in market that can remove hairs of different strengths. To shave, water is mixed with the powder to form a paste which is then applied on the hairy part for about 5 minutes and finally washed with water to remove unwanted hair and the spent paste. A common active ingredient in chemical depilatories of which shaving powder is an example is calcium thioglycolate, which weakens the hair by breaking down the disulphide bonds in keratin so that the hair is easily cut off where it emerges from the hair follicle [2, 3].

Otuchere and Odey [4] conducted a study on the use of shaving power and observed that shaving powders contain some substances that can induce mutagenicity in the cells of the skin. Melanocytes, the pigment producing cells located in the epidermis of the skin are destroyed by these

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substances. This renders melanocytes.incapable of producing further pigments that give the hair its dark colour and therefore resulted in grey hair observed after a prolonged use of these depilatories [5].

Gamma radiation plays a significant role in the manufacture of cosmetic products. Gamma radiation is used in the control or prevention of microbial contamination [6]. Gamma radiation is used as an alternative technique to sterilize/decontaminate raw materials and products [7]. However, gamma radiation used in this process does not leave any residual radioactivity or make something radioactive. It has been observed that radiation poses health hazard and can cause many different kinds of diseases, especially cancer [8. 9].

Trace elements like zinc, iron, copper, selenium and manganese are essential. They are needed by the body to function properly when absorbed in little quantity but toxic in large amounts. For example, a very little amount of zinc in the body can result to poor health, reproductive problems and reduced resistance to diseases. On the other hand, a very large amount of zinc can also be harmful to health [10]. Chronic diseases caused by copper are very rare and available reports implicat it with liver disease [11].

Reports or data on the natural radioactivity of depilatories especially shaving power are very scarce. Little is also known about the trace metals content of shaving power. The only reported study [5] devoted to this subject used instrumental nuclear activation analysis (INAA) and did not considered some important elements like Cu, Se and Mn. Therefore, in the present study, natural radioactivity and trace elements in some brands of shaving power were determined, in order to evaluate their radiological effects and health hazard.

MATERIALS AND METHODS

Sample collection

Two brands of shaving powder commonly marketed in Nigeria were analyzed in this study. The samples were coded to protect the rights of the manufacturers for the contents of their products. The samples are the full strength brand coded as R and the extra strength brand coded as M for the purpose of this study.

Determination of radionuclides

Cylindrical thin-walled plastic containers of about 7.5 cm diameters were washed rinsed with dilute nitric acid and dried to avoid contamination. These were then filled with 80 g of shaving powder and later sealed for at least 28 days to ensure that no loss of radon gas occurred, thereby ensuring that the state of secular equilibrium was reached between radium isotopes and their respective daughters.

Gamma spectrometric measurements of the samples were carried out using a well calibrated NaI(Tl) detector system at the Centre for Energy Research and Development, OAU Ile Ife. Gamma counting was done for 7 hours (25200 seconds). The method employed in this analysis is the Comparative Method. This involves the use of a reference sample. The standard reference sample is IAEA-375 for soil sample [12].

Triplicate analyses of the samples were carried out to ensure reproducibility of the results and the stability of the counting system.

Sample preparation for AAS analysis

The samples were subjected to digestion process prior to atomic absorption spectrometric (AAS) analysis. The digestion was carried out by accurately weighing 0.5 g of each shaving powder and 5 mL of concentrated nitric acid (HNO_3) was added and heated at about 150 $^{\circ}$C for 45 minutes on a hot plate. About 5 mL of a mixture of nitric acid: perchloric acid in a ratio of 3:1 (v/v) was added and heated further until the sample was completely digested. The digestion was carried out in triplicate and the aqueous solution was analysed using atomic absorption spectrophotometer (AAS).

Determination of trace metals by ED-XRF

About 5 g of each shaving powder was weighed and analysed in triplicate using Amptek PX2CR model Energy Dispersive X-ray Fluorescence (ED-XRF) linked with a multi-channel analyser (MCA). The first stage is sample preparation; a 13 mm (0.64 g) pellet of the sample was formed using a CARVER model manual pelletizing machine at a pressure between 6-8 torr. The pelletized sample was inserted into the sample holder of the XRF system and was bombarded by the X-ray fluorescence produced from the X-ray tube source at a voltage of 25 KV and current of 50 µA for 1000 counts or approximately 18 minutes. The analytes were detected by a solid state Si-Li detector system. The spectrum analysis was done using the ADMCA plus FP-CROSS Software which relates the peak areas into respective elemental concentration values.

RESULTS

The data reported here are the averages of three independent measurements with samples of the same weight taken from the same container.

Natural radioactivity in shaving powder

Activity concentration

Table 1 presents the activity concentrations of the radionuclides identified in the shaving power samples. The results showed that the radionuclides identified belonged to decay series of the natural radionuclides of ^{238}U and ^{232}Th as well as the non-decay series ^{40}K. ^{40}K accounted for the largest contribution to the radionuclides present in all the brands of shaving powder analyzed.

The activity concentration of ^{40}K ranged from 1667.78 - 3224.16 Bq kg^{-1} with a mean value of 2445.97 ± 9.29 Bq kg^{-1}. The activity concentration of ^{238}U varied from 136.10 - 494.21 Bq kg^{-1} with an average value of 315.16 ± 17.72 Bq kg^{-1}. ^{238}U was the second highest contributor to the total radionuclides in the shaving powder samples. ^{232}Th had the least concentrations, which varied from 31.05 - 69.84 Bq kg^{-1} with a mean value of 50.45 ± 1.79 Bq kg^{-1}.

Absorbed dose rate

The absorbed dose rates in air calculated from the activity concentration of each sample are presented in Table 2. The values of absorbed dose rate ranged from 174.01 - 494.52 ±226.3 n Gyhr^{-1} with a mean value of 334.27 n Gyhr^{-1}, which is higher than normal background radiation. Normal background radiation ranges approximately between 30 and 70 n Gyhr^{-1} [13].

Table 1. Activity concentration of radionuclides (Bq kg^{-1}) in shaving powder.

Sample	^{40}K	^{238}U	^{232}Th
R	1667.78 ± 9.47	136.10 ± 28.87	31.05 ± 3.53
M	3224.16 ± 9.34	494.21 ± 41.41	69.84 ± 3.60
Mean	2445.97 ± 9.29	315.16 ± 17.72	50.45 ± 1.79

Table 2. Absorbed dose rates in the shaving powder samples calculated from the activity concentration of radionuclides in the samples.

Sample	Absorbed dose rate (n Gyhr^{-1})	Equivalent dose (m Svyr^{-1})
R	174.01	1.53
M	494.52	4.34

Trace metals in shaving power

The concentrations of five elements determined in two brands of shaving powder marketed in Nigeria are presented in Tables 3 and 4 as AAS and ED-XRF results, respectively. The results of both AAS and ED-XRF showed that Iron had the highest concentration in the two brands of shaving powders while selenium had the least concentration. From the AAS results, manganese and selenium are present in higher concentrations in brand R shaving powder than in brand M, while copper, iron and zinc had higher concentrations in brand M than in brand R

(Figure 1). From the ED-XRF results, all the elements except manganese had higher concentrations in brand R than in brand M (Figure 2). The trends of occurrence of the elements from the AAS results of both brands of shaving power are similar; Fe >Mn >Zn>Cu>Se (100% correlation). This suggests that the ratio of their ingredients formulation is similar. However, this trend is slightly altered in ED-XRF results. The concentrations of the elements were higher in both brand R and brand M using ED-XRF method than using AAS method (Figures 3 and 4).

Table 3. Results of analysis of shaving powder using AAS.

Elements	Brand R (μg g^{-1})	Brand M (μg g^{-1})
Zn	272.25 ± 34.20	299.30 ± 64.15
Cu	50.18 ± 4.14	50.32 ± 9.60
Fe	373.17 ± 118.35	378.55 ± 99.55
Se	0.5 ± 0.13	0.42 ± 0.10
Mn	314.55 ± 68.20	307.48 ± 50.15

Table 4. Results of analysis of shaving powder using X-Ray Fluorescence.

Elements	Brand R (μg g^{-1})	Brand M (μg g^{-1})
Zn	1387.33 ± 134.13	1048 ± 124.43
Cu	1314.33 ± 138.58	1259.33 ± 145.07
Fe	8437.33 ± 458.51	3192 ± 298.78
Se	267 ± 58.52	196.33 ± 51.61
Mn	1114 ± 188.25	1353.66 ± 225.41

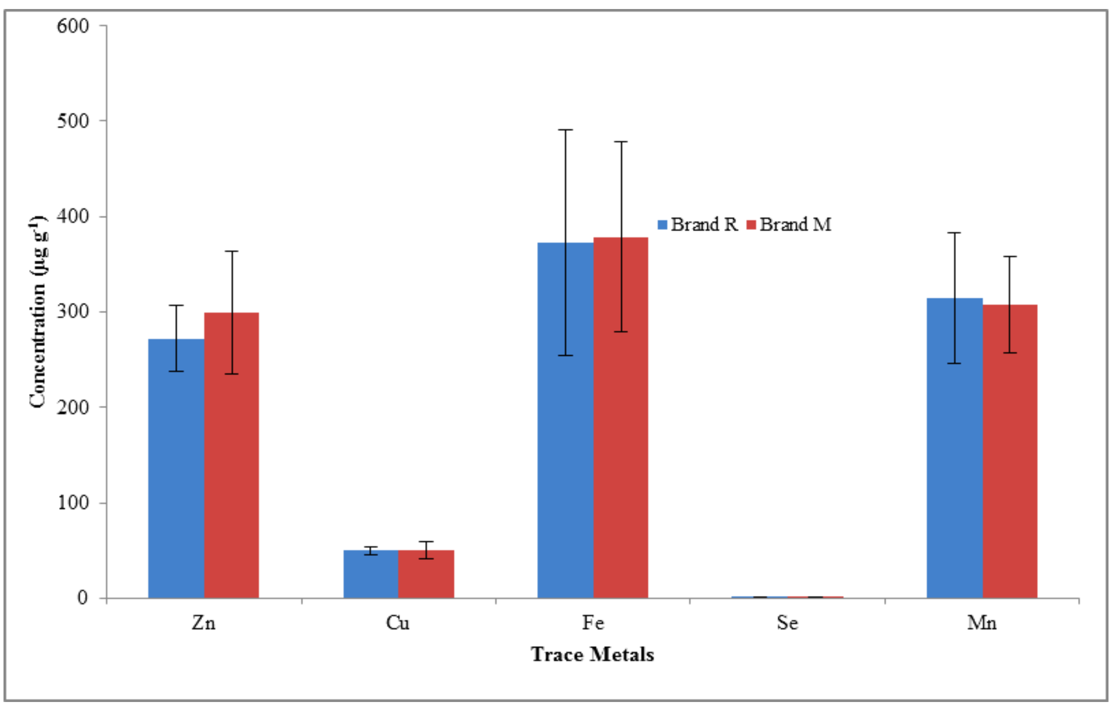

Figure 1. Relative concentrations of trace metals in shaving powder of brand R and brand M from AAS analysis.

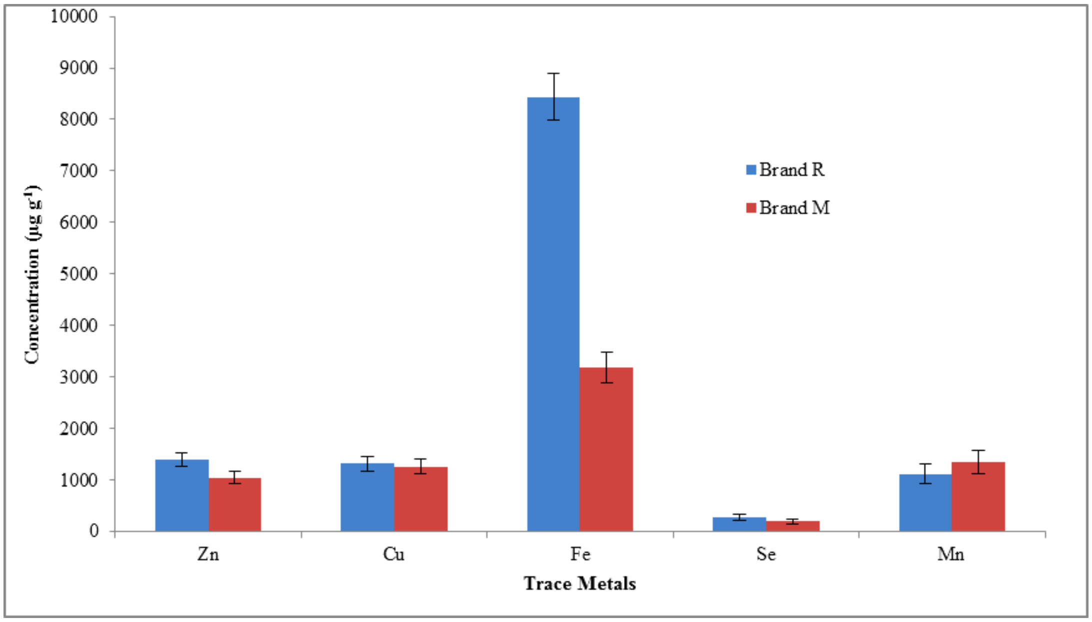

Figure 2. Relative concentrations of trace metals in shaving powder of brand R and brand M from EDXRF analysis.

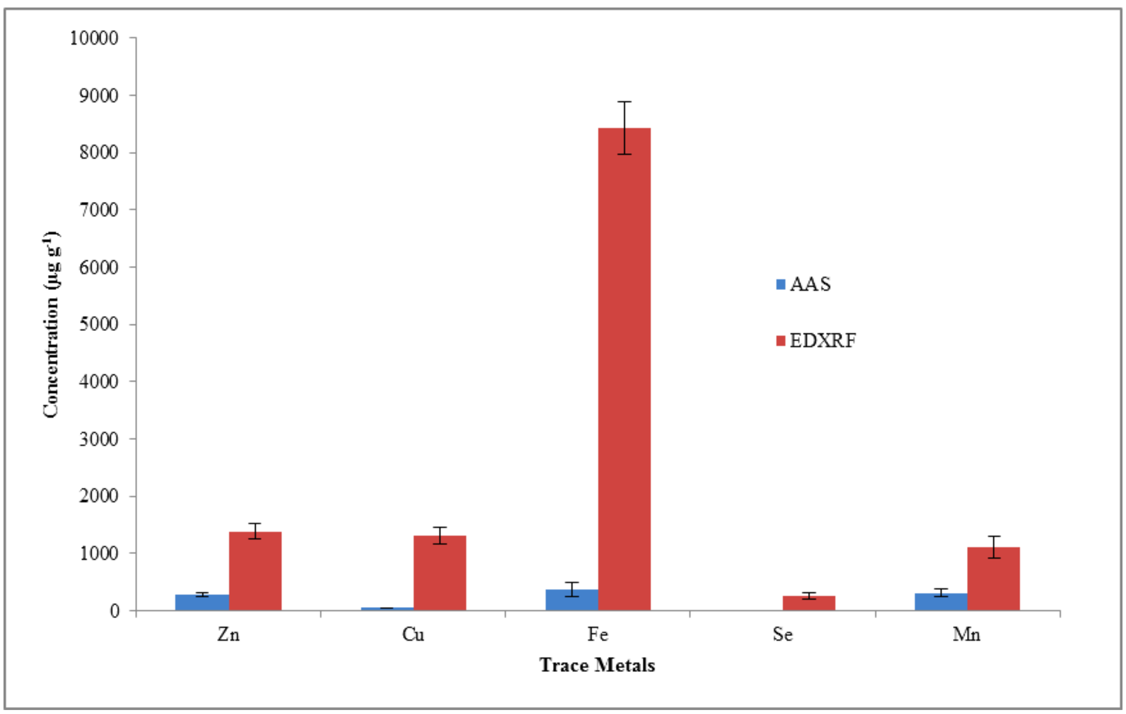

Figure 3. Comparison of measurement of concentrations of trace metals in Brand R shaving powder using AAS and EDXRF.

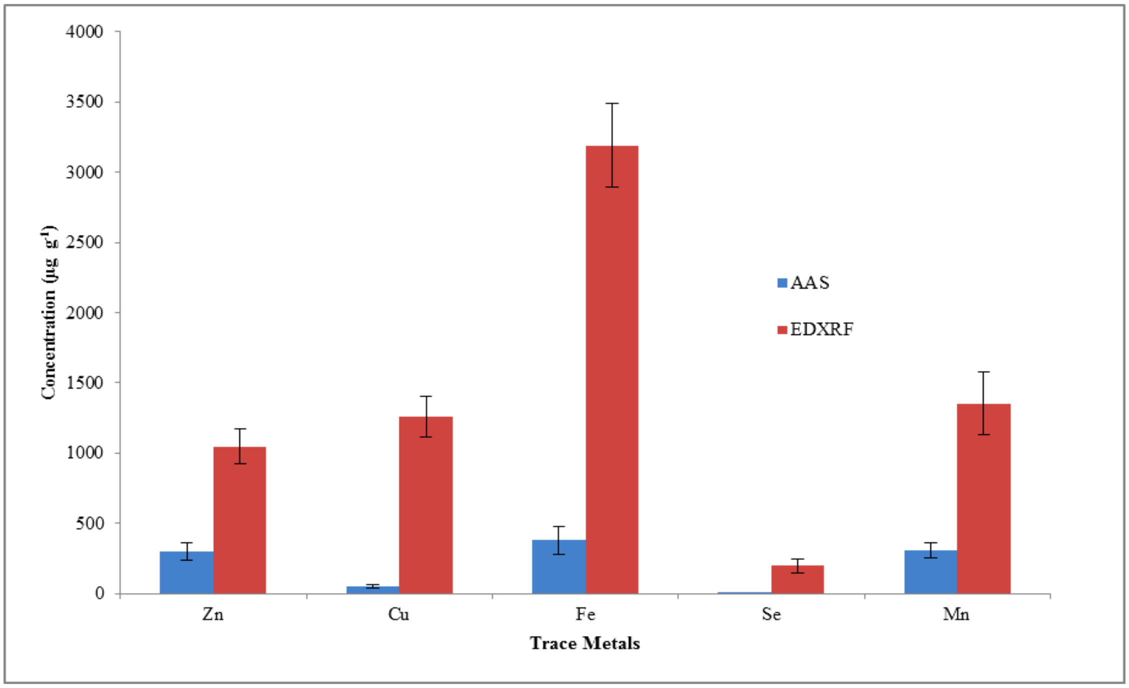

Figure 4. Comparison of measurement of concentrations of trace metals in Brand M shaving powder using AAS and EDXRF.

DISCUSSION

Health implications of radionuclides in shaving power

The activity concentrations of the radionuclides in all the samples were above the limit of background radiation. In comparison with the worldwide reported values of average activity concentrations of 370 Bq kg^{-1} for ^{40}K, 40 Bq kg^{-1} for both ^{232}Th and ^{238}U in soil [14], the activity concentrations of ^{40}K and ^{238}U are greater than the UNSCEAR limits in the two brands of shaving power. ^{232}Th activity concentration in brand M is greater than the UNSCEAR limit while it is less than the UNSCEAR limit in brand R. The activity concentrations of the radionuclides (^{40}K, ^{238}U and ^{232}Th) are significantly higher in brand M than in brand R (Figure 5). The high concentrations of the radionuclides in the shaving power will enhance the radiological health burden effects on the users.

The possible biological effect of the absorbed dose rate can be understood by converting it into the equivalent dose which is measured in Sievert (Sv). The absorbed dose rate was multiplied by a radiation-weighting factor, which is 1 for gamma radiation and 20 for alpha radiation because 1 Gy of alpha radiation is about 20 times more severe than 1 Gy of gamma radiation. Table 2 shows the calculated absorbed dose rate in n Gyhr^{-1} and the corresponding equivalent dose rate in m Sv year^{-1}, using 365.25 days as the total number of days in a year. The equivalent dose ranged from 1.53 to 4.34m Svyr^{-1} with a mean of 2.94±1.98 m Svyr^{-1}. In comparison with the dose limit of 1 m Svyr^{-1} set by ICRP, the equivalent dose values obtained in this study are high, which suggests intrinsic health hazard to the users of shaving powers.]

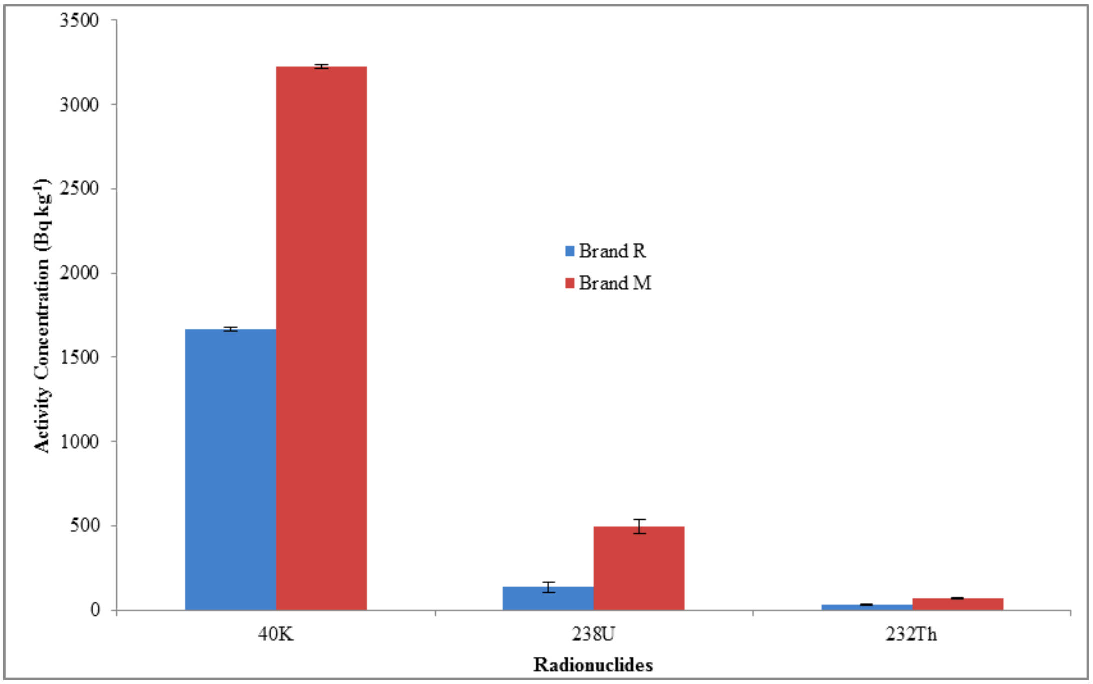

Figure 5. Comparison of activity concentrations of radionuclides in Brand R and Brand M shaving powder.

Health implications of trace metals in shaving power

Apart from the growth of grey hair on the part of the skin where shaving powders were applied after its use over a long period of time [5. 6], there may be some other health risk that may be associated because of the levels of trace elements present in the shaving powders. There are possibilities that these elements in the shaving powder are absorbed into the body through the sweat glands on the skin [5].

The lowest mean value of Zn from the two analytical methods employed was 272.25 ± 34.2 ppm (Tables 3 and 4), which exceeds the permissible exposure limit of 5 mgm^{-3} [15]. According to ATSDR [10], the amount of zinc that passes through the skin is relatively small compared to inhalation and consumption. And, zinc normally leaves the body in urine and faeces. The possibility of inhaling zinc is high during application of shaving power especially when it is dried before washing. Although, we did not check for the amount of zinc absorbed during shaving and also did not check for the exact amount that leaves the body, the probability of the body retaining more than the permissible limit is very high.

In the two brands of shaving power using both AAS and ED-XRF, the least mean concentration of copper was 50.18 ± 4.1 ppm (Tables 3 and 4), which exceeds the permissible exposure limit of 0.1 mg m$^{3-1}$ [15]. A man who shaves everyday will apply an average of 1000 g of shaving powder to the skin in one year, which means he will be exposed to about 0.137 mg of copper daily. This is relatively higher than the permissible exposure limit of OSHA [15], considering the fact that this is in addition to that obtained from his daily intake from food. However, the health risk from this exposure will depend on daily copper intake from other sources like food and amount of copper excrete from the body considering the report of Copper Development Association [11[, which says that humans excrete about 2.0 to 2.5 mg of copper daily in faeces, urine, skin, saliva and menses.

The lowest mean value of iron in the two brands of shaving power analysed was 373.17 ± 118.3 ppm (Tables 3 and 4), which exceeds the permissible exposure limit of 10 mg m$^{3-1}$ [15]. Considering the lowest mean value, a man that uses shaving power daily will be exposed to 1.02 mg of iron per day (Table 3), and if highest mean value is considered (Table 4), the man will be exposed to 23.12 mg day^{-1}.

An estimated minimum daily requirement for iron range from about 10 to 50 mg day^{-1}, which depend on age, sex, and physiological status [16]. Finch and Monsen [17] reported that an intake of 0.4–1 mg kg^{-1} of body weight per day is unlikely to cause adverse effects in healthy persons. Therefore, the iron content of the two brands of shaving power analyzed is likely to have harmful effects.

The lowest mean measured amount of selenium from AAS and ED-XRF in the two brands of shaving power was 0.42 ± 0.1 ppm (Tables 3 and 4). This value exceeds the permissible exposure of 0.2 g m^{3-1} for selenium [16]. This result indicates that a man who uses shaving power daily will be exposed to daily possible intake of 1.15 µg of selenium, which is far below the daily recommended intake of 35 µg for an adult male [18]. Therefore, the amount of selenium present in the shaving power is not likely to have any harmful effects, if the lowest value is considered but would be harmful if the highest value is considered.

The lowest mean concentration of manganese in the two brands of shaving power from both AAS and ED-XRF was 307.48 ± 50.1 ppm (Tables 3 and 4). This value far exceeds the permissible limit of exposure of 5 mg m^{3-1} [15]. The results of this study indicate that a person using shaving power daily may be exposed to a minimum daily intake of 0.84 mg of manganese.

Natural radioactivity and trace elements can have a special application in medical diagnostic aspects [19-24] because trace elements can be used in radiation therapy as well as their therapeutic properties in the treatment of diagnostic medical disorders [25-27].

CONCLUSIONS

A chemical evaluation of two brands of shaving power commonly used in Nigeria showed the presence of some radionuclides decay series that include ^{238}U and ^{232}Th and non-decay series, ^{40}K. The study also showed high concentrations of trace elements (Cu, Fe, Mn, Se and Zn). The two brands of shaving power evaluated have radioactivity level that is above the acceptable limit. Also, the concentrations of the trace elements are present at levels above the permissible exposure limits. Both natural radioactivity and trace elements in the two brands of shaving power commonly used in Nigeria can pose health risk.

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Conflict of interests

The authors have no conflict of interest.

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