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Full Length Research Paper

Radioactivity of local tobacco and some selected brands of cigarettes

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This study investigated the radioactivity levels of locally consumed tobacco and three (3) popular brands of cigarettes. The Ortec X-ray fluorescence spectroscopy (XRF) with model number XL12170 was used to determine the radioactivity and elemental composition of each of the samples. All the samples were found to be radioactive with the following elements, including-K, Ca, Ti, Cr, Mn, Fe, Pb, Rb, Sr, Zr and Nb. From the analysis, it was observed that the locally consumed tobaccos have a higher radioactive nature than the selected brands of cigarettes and this was ascribed to their different methods of processing/techniques.

Key words: Radioactivity, background radiation, X-ray fluorescence spectroscopy, radioactive elements, alpha radiation.

INTRODUCTION

Tobacco is an agricultural product processed from fresh leaves of plants in the *genus Nicotania*. It contains minute quantities of radioactive isotopes that pose a radiation exposure hazard to those who intentionally or passively inhale it. Smokers inhale the Polonium (a radioactive component of tobacco), which settles in “hot spots” in the lungs and can cause cancer (Naomi and Erik, 2010). This is because, Po-210 emits alpha particles upon its decay and this radiation has a very destructive effect on tissues because virtually all of its very high ionizing energy is expended within the tissue. Due to its double positive charge, limited range in tissue and enormously high energy, an alpha particle can produce huge numbers of ion pairs in substances with which it interacts (Winickoff et al., 2009). Its effects may lead to thousands of deaths a year.

Basically, the most common usage of tobacco and its products is for smoking in the form of a cigarette or cigar.

Tobacco is commercially available in dried, cured and natural forms. In addition to been consumed as cigarettes and cigars, it can be smoked in a stem pipe, water pipe or hookah. Tobacco can also be chewed “dipped”, or sniffed into the nose as finely powdered snuff.

According to the World Health Organization, radiation from tobacco smoke is the second biggest cause of death worldwide, just between hunger and malaria, having killed 100 million people in the 20th century (Kilthau, 1996).

All methods of tobacco consumption results in varying quantities of radiation to be absorbed into the smokers bloodstream. This exposes the smoker to a level of radiation that over time leads to several ailments like cancer, ulcer, leukemia and many other diseases (Ponte, 1986). Thus many countries set a minimum smoking age, regulating the purchase and use of tobacco products. Therefore, the basic aims and objectives of this work include the following:

(i) To determine the level of radioactivity in local dried tobacco and some brands of cigarettes.
(ii) To ascertain the elemental composition of all samples of tobacco chosen.
(iii) To obtain the radiation dose levels from the dried tobacco and brands of cigarettes.

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Table 1. The elemental composition of sample A using XRF.

Element(s)	Energy (keV)	Intensity (C/S)	Sensitivity	Concentration (Fraction)
K	3.312	0.039	6.31E+01	6.63±1.02
Ca	3.690	0.024	7.49E+01	4.99±1.12
Cr	5.411	0.014	3.35E+02	0.32±LOD
Mn	5.895	0.014	4.26E+02	0.20±00.69
Fe	6.400	0.013	5.27E+02	0.13±00.48
Pb	10.540	0.009	9.55E+02	00.25±LOD
Sr	14.142	0.019	2.69E+03	00.16±000.42
Y	14.933	0.012	2.91E+03	000.85±LOD
Zr	15.746	0.016	3.74E+03	000.93±LOD
Nb	16.584	0.014	4.06E+03	000.70±LOD

(v) To draw conclusions on the potential hazards of radioactivity in tobacco and its products.

MATERIALS AND METHODS

The X-ray fluorescence spectroscopy was used to determine the radioactive materials in the samples. Also, the following brands of cigarettes that are commonly consumed in these localities and other materials were used for the research:

1. Sample A - ST Moritz (Dunhill)
2. Sample B - Benson and Hedges
3. Sample C - Rothmans king size
4. Samples D, E and F- Locally consumed tobacco from three different towns (Makurdi, Gboko and Katsina-Ala).
5. Handling forceps
6. Disposable plastic container.

Experimental methods

Radiation measurements using X-ray fluorescence (XRF) spectroscopy

The measurements using XRF spectrometer were carried out at Center for Energy and Research Technology (CERT), Ahmadu Bello University (ABU), Zaria to measure the elemental composition and the radioactive levels of the isotopes within the samples.

Sample preparation and analysis

All the samples were concealed in cellophane bags to prevent cross contamination. They were ground manually to powder with an agate mortar and pestle to grain size of less than 125 µm at CERT. Pellets of 19 mm diameter were prepared from 0.3 to 0.5 g powder mixed with three drops of organic liquid binder and pressed afterwards at 10 tons with a hydraulic press.

Measurements were performed using an annular 25 mCi ^{109}Cd as the excitation source that emits Ag-K X-ray (22.1 keV) in which all elements with lower characteristic excitation energies were accessible for detection in the samples. The system consists furthermore of a Si(Li) detector coupled to a computer.

Quantitative analysis of the samples was carried out using the Emission-Transmission (E-T) method and it involves the use of pure target material (Mo) to measure the absorption factors in the sample. The spectra for the samples were collected for 7000 s. with the ^{109}Cd source and then evaluated using the AXIL-QXAS program for the results.

EXPERIMENTAL RESULTS AND DISCUSSION

The research has investigated the radioactivity of local tobacco and some brands of cigarettes; these locally consumed tobaccos were collected from katsina-Ala, Gboko and Makurdi towns in Benue State, Nigeria. Also, commonly consumed cigarettes brands were investigated. These brands were Benson and Hedges, St. Moritz and Rothmans.

In sample A (Table 1), K, Ca and Sr has an activity higher than Cr, Mn, Fe, Pb, Y, Zr and Nb as shown in the bar chart, Figure 1. In sample B (Table 2), K, Ca, Mn, Rb, Sr, Zr and Nb has an activity higher than Ti, Cr, Fe and Pb as shown in Figure 2. Furthermore, in sample C (Table 3), K, Ca, Fe, Rb and Sr has an activity level higher than Ti, Cr, Mn, Pb, Zr and Nb as shown in Figure 3. It can therefore be inferred from samples A, B and C, that the activity of lead in sample C is higher than that in samples A and B. In sample D (Table 4), K, Ca, Fe, Rb and Sr are more in activity compared to Ti, Cr, Mn, Pb, Zr and Nb as shown in Figure 4. Also, in sample E (Table 5), K, Ca, Fe, Rb, Sr and Zr are more in activity than Ti, Cr, Mn, Pb, and Nb as shown in Figure 5. In sample F (Table 6), K, Ca, Fe, Sr and Zr are more in activity than Ti, Cr, Mn, Pb, Rb and Nb as shown in Figure 6. The isotope of lead which is seventh in the line spectrum has an activity which is quite small compared to the other radioisotopes in all the samples (Tahir and Alaamar, 2008). However, as a beta emitter, the isotopes of lead is an emitting precursor of Po-210 which is highly concentrated in tobacco trichomes and the trichome combustion in burning cigarettes produces insoluble, Pb-210-enriched particles in mainstream smoke (Monique et al., 2008). Hence the high concentration of Po- 210 observed at segmental bifurcations is as a result of the persistence of insoluble isotopes of lead enriched

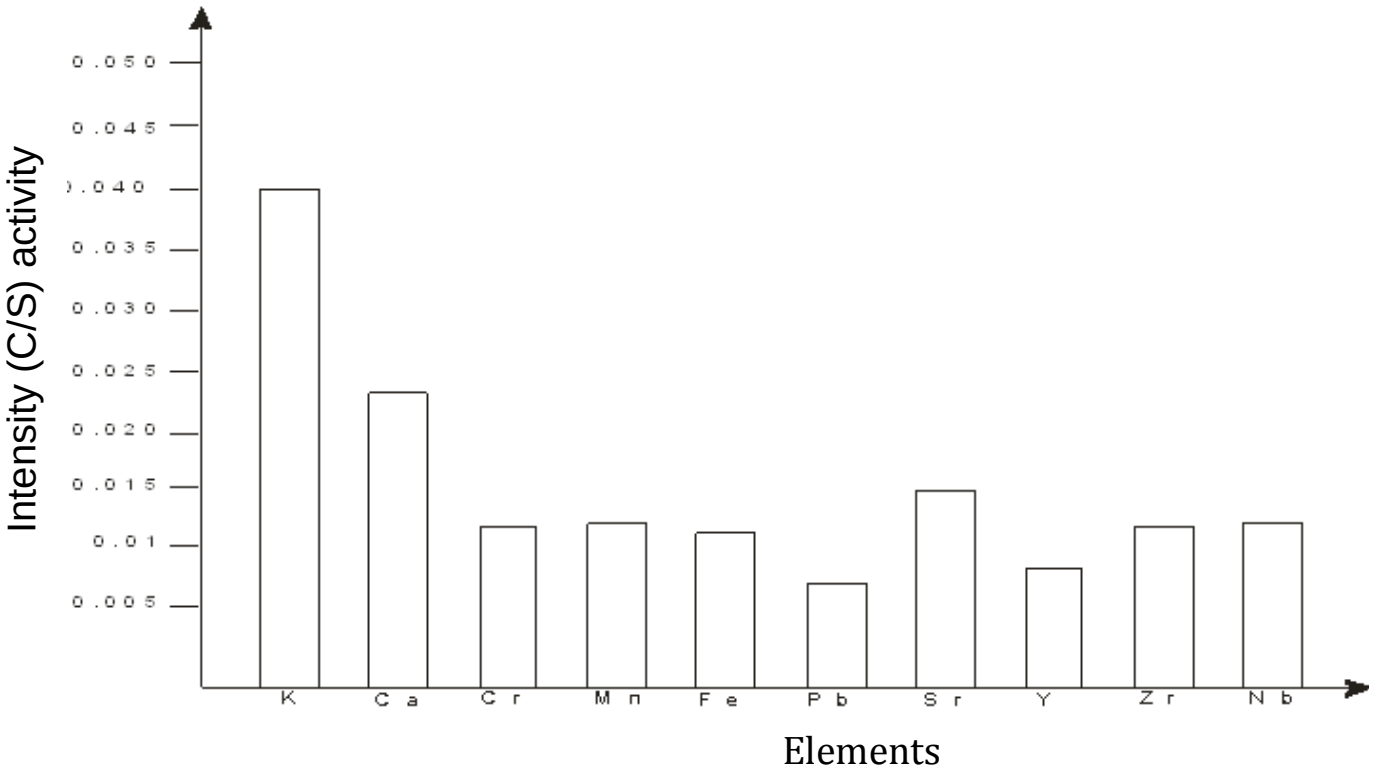

Figure 1. The bar chart of elemental composition for sample.

Table 2. The elemental composition of sample B using XRF.

Element(s)	Energy (keV)	Intensity (C/S)	Sensitivity	Concentration (Fraction)
K	3.312	0.025	6.60E+01	3.97±0.84
Ca	3.690	0.027	7.84E+01	4.24±0.86
Ti	4.508	0.010	1.80E+02	0.58±LOD
Cr	5.411	0.009	3.51E+02	0.18±LOD
Mn	5.895	0.015	4.46E+02	0.18±00.54
Fe	6.400	0.013	5.52E+02	0.11±LOD
Pb	10.540	0.011	9.99E+02	00.26±LOD
Rb	13.375	0.025	2.58E+03	00.21±LOD
Sr	14.142	0.029	2.81E+03	00.21±000.38
Zr	15.746	0.016	3.91E+03	000.80±LOD
Nb	16.584	0.015	4.24E+03	000.69±LOD

particles deposited at segmental bifurcations and by ingrowths of Po-210 in these particles after a long period of time (Purkayastha and Bhattacharyya, 1975).

Furthermore, from the brands of cigarettes selected, even though the isotope of lead are at a low limit of detection (LOD), a long period of exposure will bring about a malignant transformation by alpha interaction with basal cells leading to the cause of the several ailments mentioned previously. Now, considering the locally consumed tobacco and the selected brands of cigarettes, the level of radiation in the locally consumed tobacco in Katsina-Ala town is slightly higher due to high levels of K, Ca, Fe, Rb, Sr and Zr compared to the others from Gboko and Makurdi towns. Also, sample C (Rothmans king size) has a higher level of radiation compared to samples B and D (St. Moritzs and Benson Hedges). This could be attributed to differences in the application and use of chemical fertilizers and non-toxic

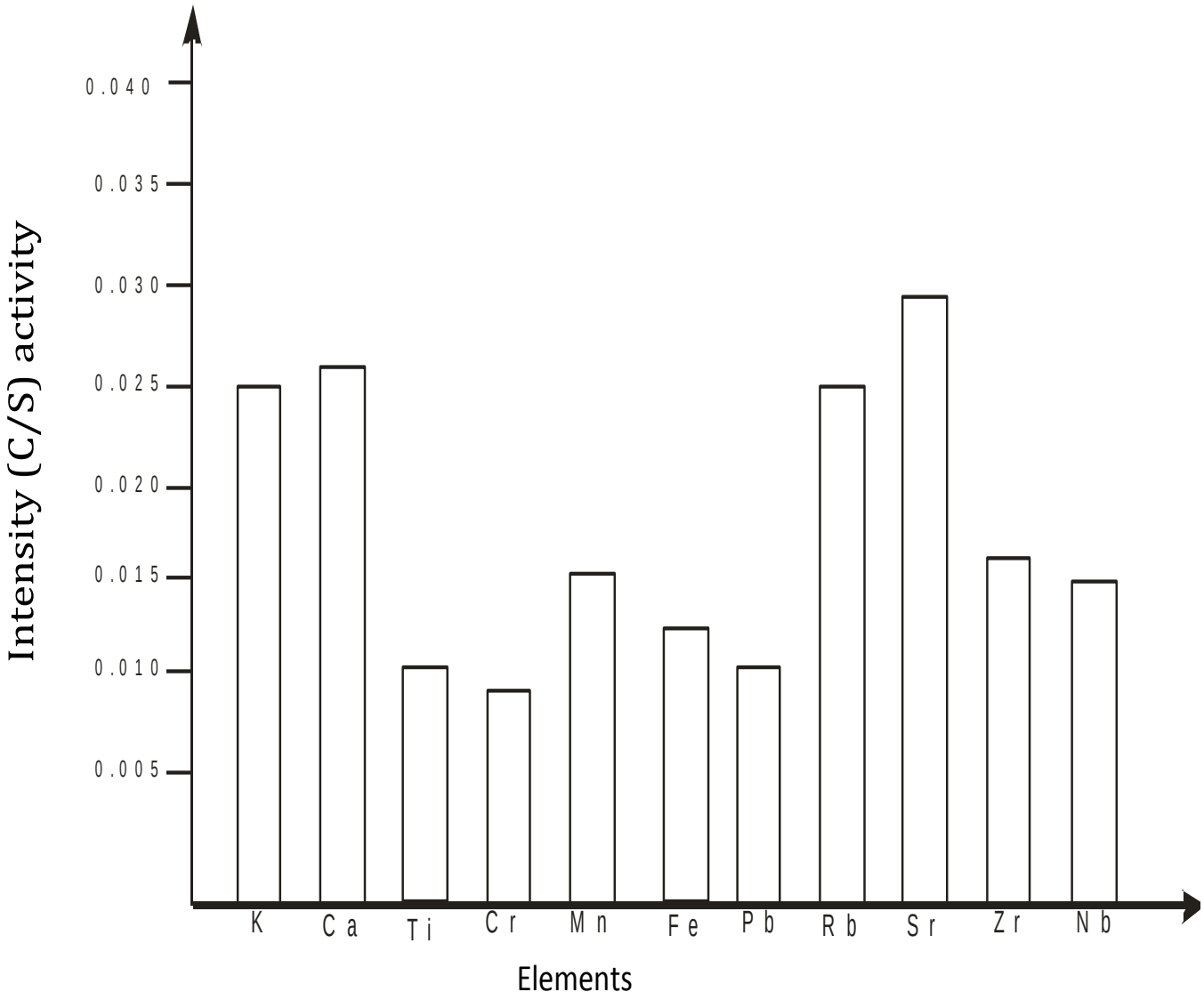

Figure 2. The bar chart of elemental composition for sample B.

Table 3. The elemental composition of sample C using XRF.

Element(s)	Energy (keV)	Intensity (C/S)	Sensitivity	Concentration (Fraction)
K	3.312	0.033	6.60E+01	5.22±0.92
Ca	3.690	0.028	7.84E+01	4.99±0.99
Ti	4.508	0.010	1.80E+02	0.66±LOD
Cr	5.411	0.011	3.51E+02	0.23±LOD
Mn	5.895	0.013	4.46E+02	0.18±LOD
Fe	6.400	0.015	5.52E+02	0.15±00.44
Pb	10.540	0.010	9.99E+02	00.28±LOD
Rb	13.375	0.019	2.58E+03	00.17±LOD
Sr	14.142	0.020	2.81E+03	00.65±000.42
Zr	15.746	0.014	3.91E+03	000.82±LOD
Nb	16.584	0.011	4.24E+03	000.61±LOD

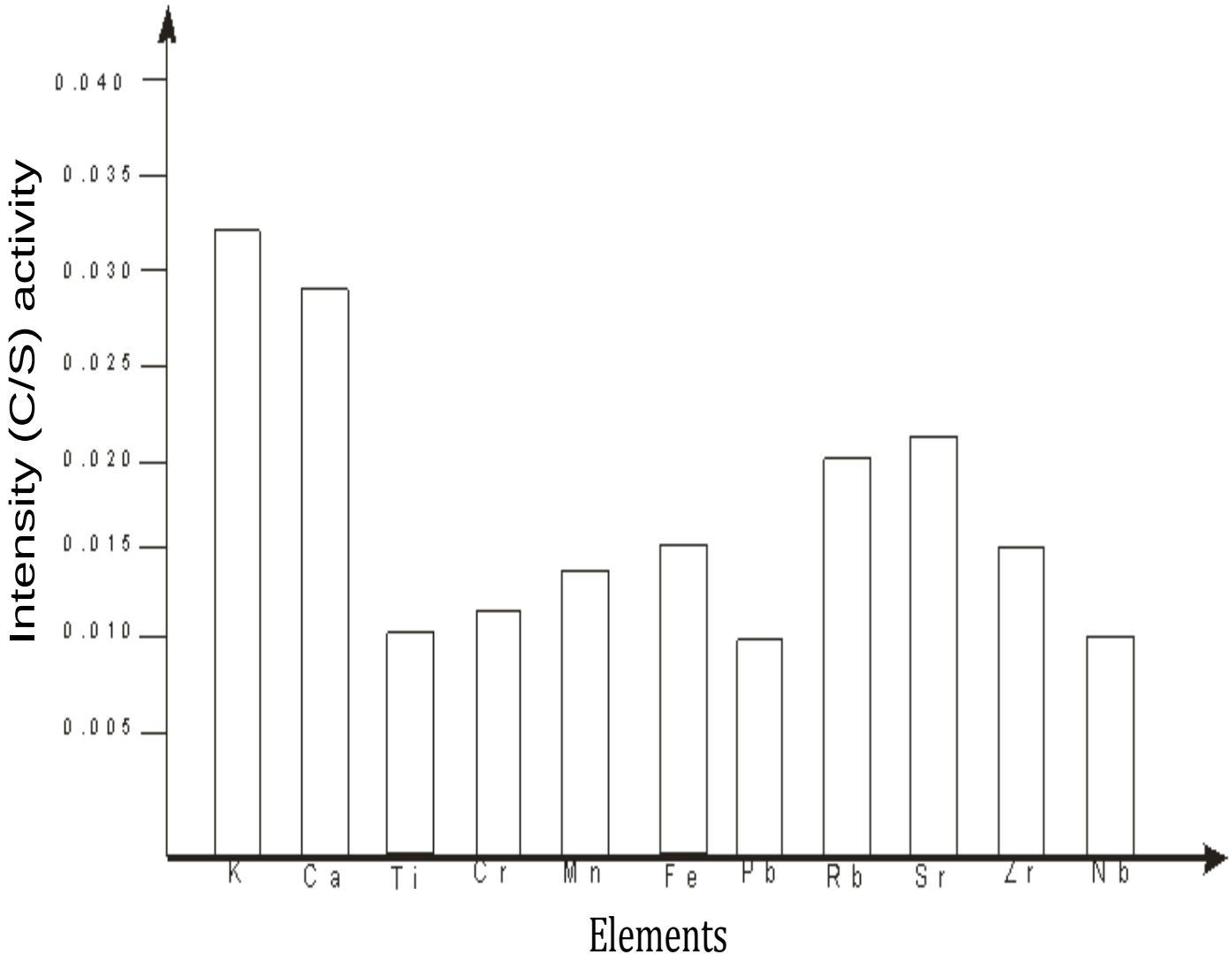

Figure 3. The bar chart of elemental composition for sample C.

Table 4. The elemental composition of sample D using XRF.

Element(s)	Energy (keV)	Intensity (C/S)	Sensitivity	Concentration (Fraction)
K	3.312	0.025	6.91E+01	3.71±0.99
Ca	3.690	0.050	8.21E+01	7.58±1.12
Ti	4.508	0.017	1.89E+02	1.12±0.41
Cr	5.411	0.013	3.67E+02	0.29±LOD
Mn	5.895	0.015	4.67E+02	0.21±LOD
Fe	6.400	0.054	5.78E+02	0.54±06.81
Pb	10.540	0.010	1.05E+03	02.68±LOD
Rb	13.375	0.025	2.71E+03	02.11±LOD
Sr	14.142	0.032	2.94E+03	02.45±004.90
Zr	15.746	0.015	4.10E+03	008.13±0032.27
Nb	16.584	0.016	4.44E+03	00.748±LOD

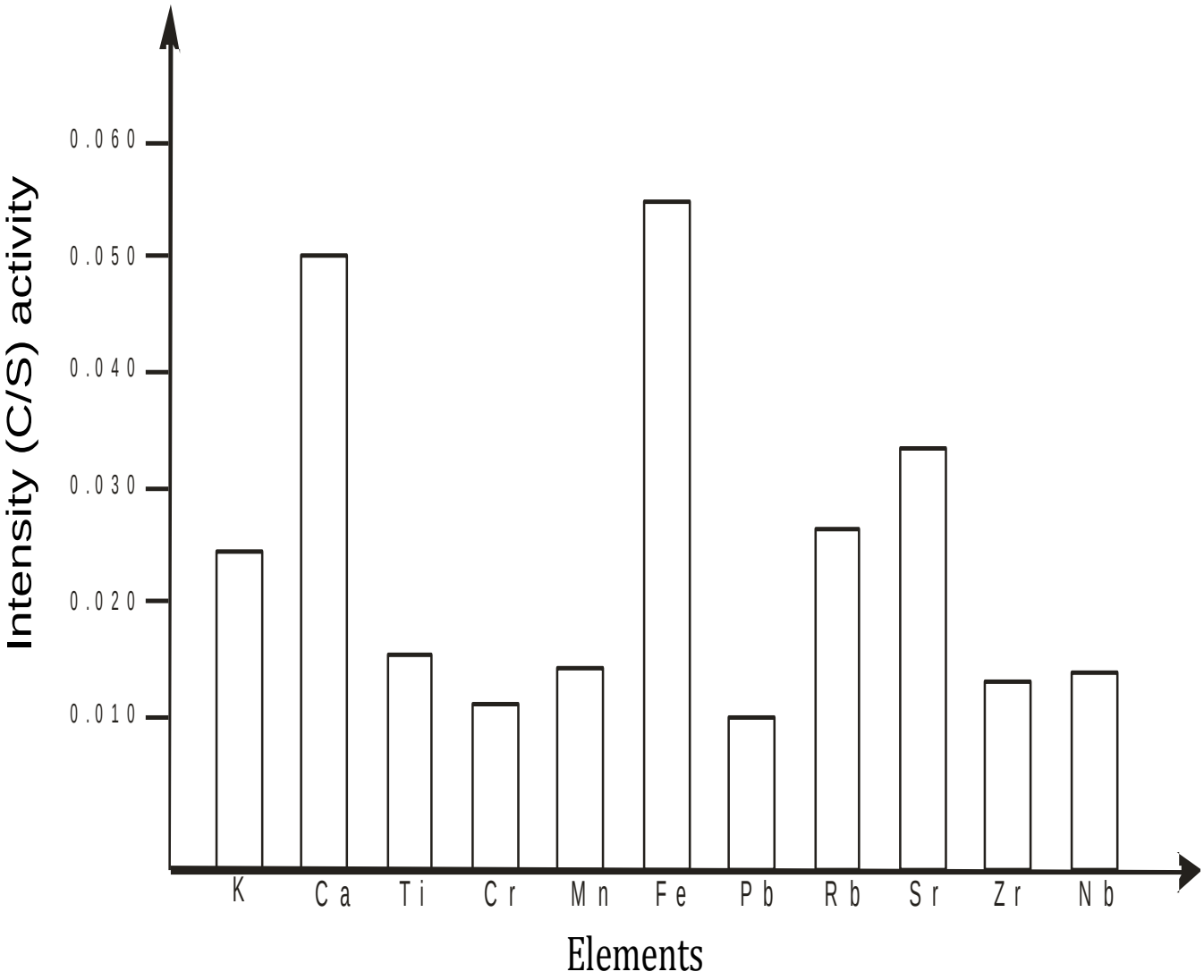

Figure 4. The bar chart of elemental composition for sample D.

Table 5. The elemental composition of sample E using XRF.

Element(s)	Energy (keV)	Intensity (C/S)	Sensitivity	Concentration (Fraction)
K	3.312	0.022	6.60E+01	3.52±0.86
Ca	3.690	0.034	7.84E+01	5.28±0.89
Ti	4.508	0.013	1.80E+02	0.75±LOD
Cr	5.411	0.013	3.51E+02	0.26±LOD
Mn	5.895	0.013	4.46E+02	0.16±LOD
Fe	6.400	0.052	5.52E+02	0.47±00.52
Pb	10.540	0.009	9.99E+02	00.24±LOD
Rb	13.375	0.028	2.58E+03	00.25±LOD
Sr	14.142	0.027	2.81E+03	00.21±000.42
Zr	15.746	0.029	3.91E+03	00.16±000.31
Nb	16.584	0.012	4.24E+03	000.60±LOD

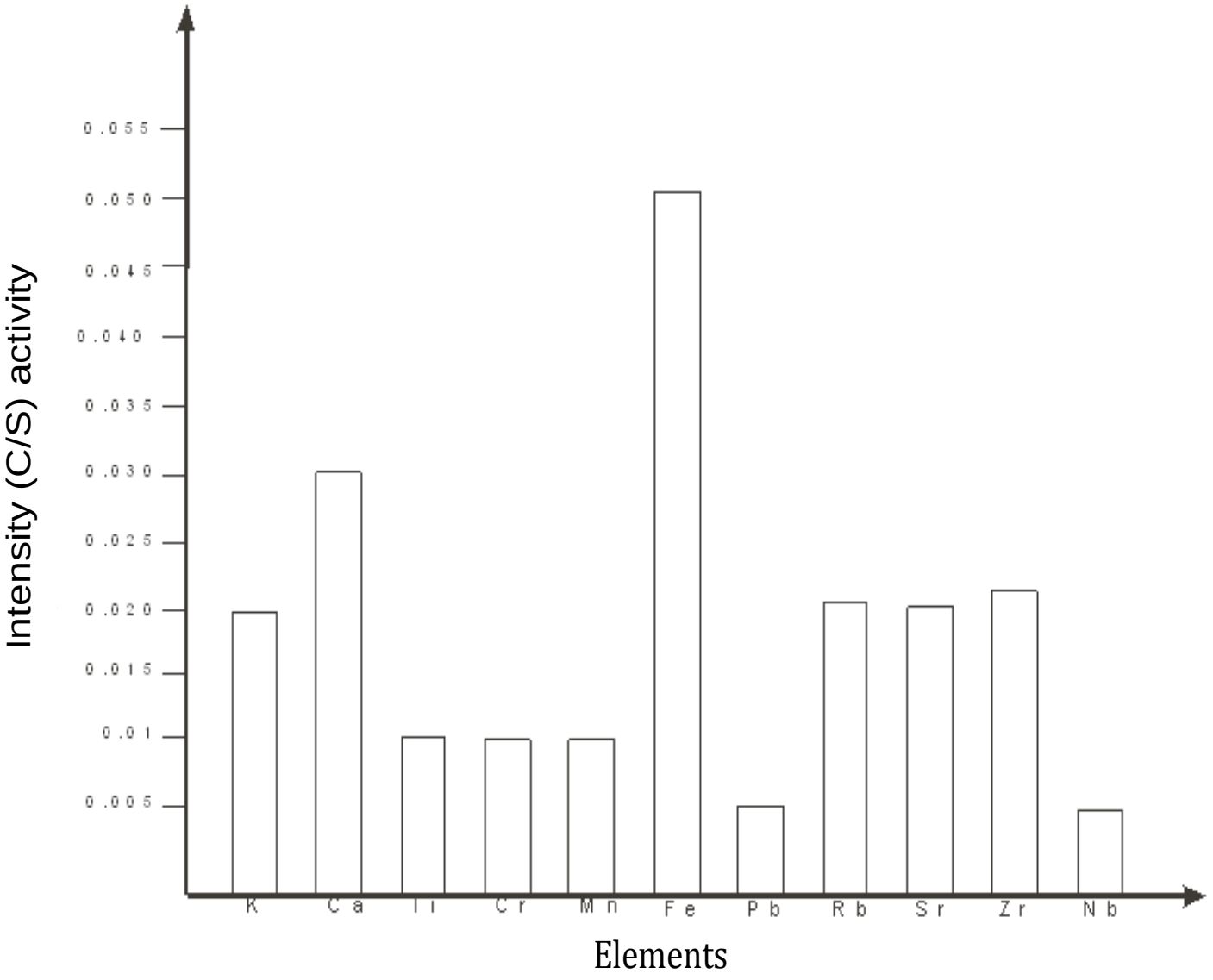

Figure 5. The bar chart of elemental composition for sample E.

Table 6. The elemental composition of sample F using XRF.

Element(s)	Energy (keV)	Intensity (C/S)	Sensitivity	Concentration (Fraction)
K	3.312	0.030	6.60E+01	4.92±0.88
Ca	3.690	0.030	7.84E+01	5.21±0.97
Ti	4.508	0.015	1.80E+02	0.94±0.32
Cr	5.411	0.010	3.51E+02	0.23±LOD
Mn	5.895	0.010	4.46E+02	0.15±LOD
Fe	6.400	0.057	5.52E+02	0.56±00.54
Pb	10.540	0.012	9.99E+02	00.34±LOD
Rb	13.375	0.020	2.58E+03	00.19±LOD
Sr	14.142	0.024	2.81E+03	00.19±000.43
Zr	15.746	0.110	3.91E+03	00.63±000.41
Nb	16.584	0.012	4.24E+03	000.64±LOD

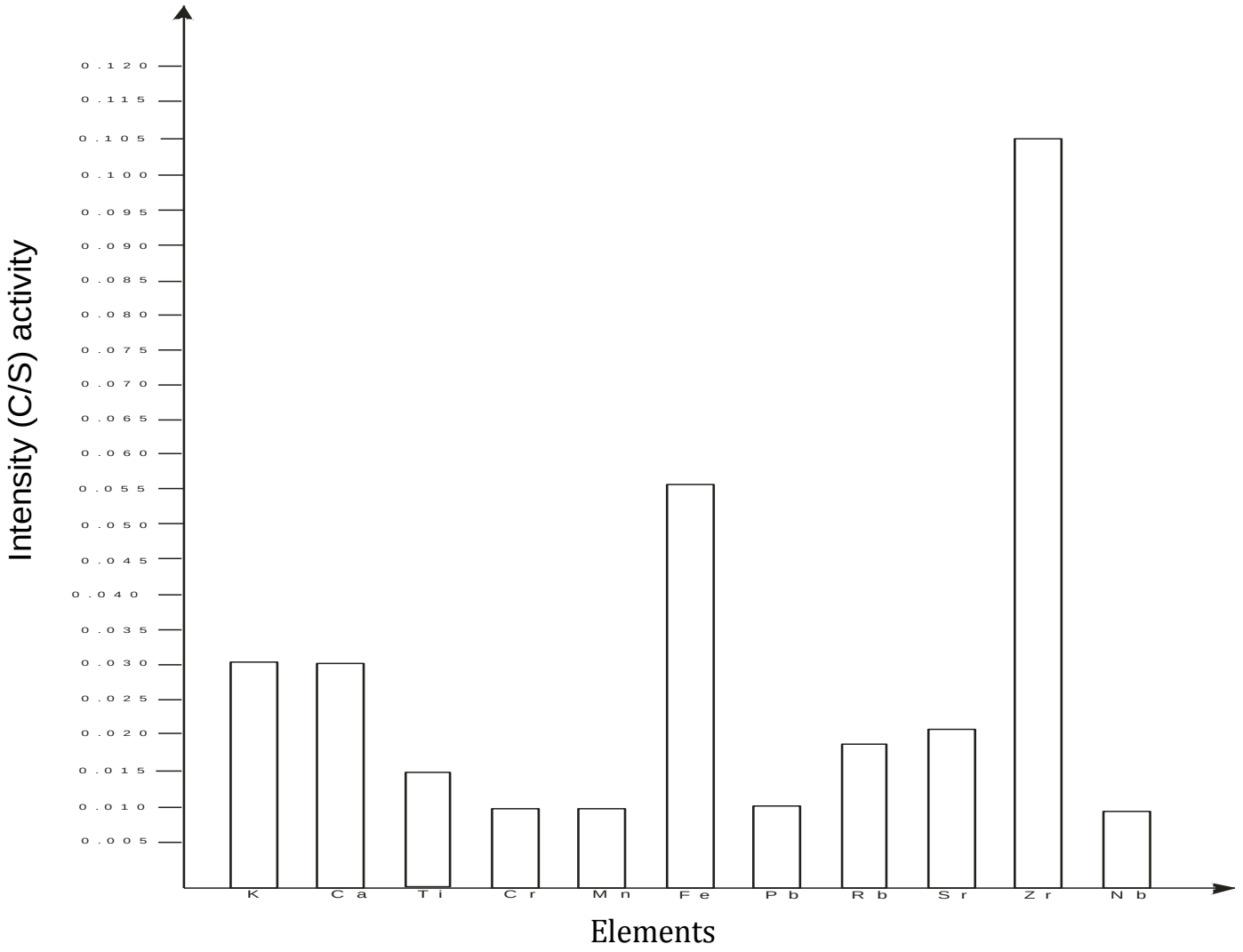

Figure 6. The bar chart of elemental composition for sample F.

pesticides, but an enhanced use of organic fertilizers which appears to emits less alpha radiation than a chemical fertilizer (Kilthau, 1996; Colgrove et al., 2011).

Since it has been proved that all the brands contain isotopes of lead (an alpha-emitter) which is a precursor to the production of polonium-210 at segmental bifurcations, then all the samples are radioactive (Martell, 1983).

Conclusion

Based on the findings of the research, it can be concluded that:

(i) All the selected brands of cigarettes and the locally consumed tobacco from the three different towns were found to be radioactive.

(ii) The mean radioactive levels of the locally consumed tobacco are found to be higher than the selected brands of cigarettes. This could be as a result of the differences in their processing techniques or methods.

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