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Natural Radioactivity of Catha Edulis (Khat) and Tobacco Plants Collected from Yemen

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Abstract:- **Chewing Catha edulis (Khat) and smoking tobacco at the same time cause a severe problem to human health. This behavior could be responsible for an array of cancer diseases, which leads to human death. For this reason, the present work aims to demonstrate the natural radioactivity distribution of Catha edulis (Khat) and tobacco plants grown in Yemen. Wavelength Dispersive X-ray Fluorescence (WDXRF) spectrometer was used to specify the chemical composition of Catha edulis and tobacco plants. The results of X-ray fluorescence experiments revealed the presence of heavy minerals in Catha edulis and Tobacco with different concentrations. In addition, the radioactivity concentrations of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K were quantified in Bq/kg for these plants using ¥-spectrometry connected with high pure germanium detector. The average concentration of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in Catha edulis were 59.5±2.40, 0.285±0.05, 50.25±4.88, 687±38.18 Bq/kg respectively. For the collected Tobacco plants the average concentrations of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in were 71.0±2.26, 0.81±0.04, 71.35±8.84, 1126.5±50.20 Bq/kg respectively. It was found that the concentrations of the natural radioactivity of tobacco plants are higher than their level in the Catha edulis plants.**

Keywords: natural radioactivity; Catha edulis; Tobacco; oral and lung cancers

I. INTRODUCTION

Under the auspices of Yemeni government, the Catha edulis (Khat) and tobacco plants are normally grown and widespread, even they are considered as a natural drug plant. In Yemen, the Catha edulis plant is popular among the majority of Yemeni people who are seeking the drug-like effect obtained through chewing the fresh leaves. Apparently, chewing Catha edulis leaves generates a drug-like effect, an intense thirst, produces excitement with deportation sleep and enhances communication between people [1]. However, it has a devastating effect on people's health because it contains cathinone, ephedrine like compounds [1] and an amphetamine-like stimulant [2-4]**.** Since 1980, Catha edulis has classified as a mild drug and not dangerous addictive [5]. Recently, an additional factor was appeared which is the smoking of tobacco during the chewing of Catha edulis leaves. On a daily basis, most of Yemeni people relax for Catha edulis chewing session. At the same time, they usually smoke cigarette and/or tobacco in a hookah (water pipe) [6,7]**.** The simultaneous behavior of chewing Catha edulis leaves and smoking of tobacco represent silent killers for Yemeni people because they have important triggering factors of the cancers of mouth and lungs as well as other diseases [8,9]. A great number of Yemeni people (10-17%) (male and female) are suffering from cancer every year [10,11] due to the instantaneous use of Catha edulis and tobacco drug plants. Tobacco contains tar and nicotine, which is a polycyclic aromatic hydrocarbons and classified as a drug and addictive compounds [12,13]**.** Furthermore, the burning of tobacco generates approximately 4000 chemical compounds [14].

In the present work, the natural radioactivity distribution in Catha edulis and tobacco plants grown in Yemen has been evaluated. To our knowledge, there is no information about the natural radioactivity distribution of Catha edulis plant in the literature. However, the natural radioactivity level of tobacco has been demonstrated [15-17]. It would be expected that, both Catha edulis and tobacco plants contain many common radioactive elements, which can interpret the important role of cancer dieses for Yemeni peoples. The radioactivities of Catha edulis and tobacco represent the most dangerous factor, whereas these two plants are used daily for more than two hours continuously [18]. Nowadays, this is not restricted only for men but also women frequently chew Catha edulis and smoking tobacco. For more information about the Catha edulis and tobacco plants, quantitative elemental analysis of Catha edulis was presented using wavelength dispersive X-ray fluorescence (WDXRF) spectrometry.

II. MATERIALS AND METHODS

A. Samples

In the present work, Catha edulis and tobacco plants (leaves and stalks) were collected from Hajjah city, Yemen. The collected plant samples were not subjected to any kind of pesticides or toxins. The collected plant samples were washed with deionised water and dried. Washing removes accumulated materials, which can contribute to isotopes. Afterward, the plant samples were dried in an oven furnace at 60 °C for 72 h, and then they were grounded into a fine powder with small particle size using agate mortar of silicon carbide. Then the plant samples are ready for measuring the radioactivity. For wavelength dispersive X-ray fluorescence spectrometry (WDXRF) analysis, the grounded samples were subjected to sieving. The dried and sieved plant samples were mixed for 3 min with a low contamination binder (Wax, $C_6H_8O_3N_2$) in a mass ratio of wax: sample of 4.0:0.9 g. The wax was used due to its low absorption and low contamination with the elements of interest. Then, the samples were transferred into aluminium cups and pressed using a hydraulic press at a pelletizing pressure of 120 KN/cm^2 for 3 min (Herzog hydraulic HTP40, UK). The pelletizing pressure value was constant for all samples. The sample pellets are 3 mm in thickness and 40 mm in diameter.

B. Radioactive instrument

The dry mass samples of Catha edulis and tobacco were used to determine the radionuclide concentration using Marinelli beaker of 1000 ml. The sample mass varied from sample to sample (40-150 g). The natural radioactivities of the samples were determined using γ-spectrometry for ^{226}Ra, ^{238}U, ^{232}Th, and ^{40}K. All the measurements were performed with a low background configuration and an intrinsic n-type germanium detector equipped with and epoxy window. Calibration efficiency was investigated using gamma ray reference standard of mixed radionuclides. Peak detection efficiencies were calculated automatically through a computer system interfaced with an 8 K multichannel analyser.

C. Wavelength Dispersive X-Ray Fluorescence Spectrometry

High performance sequential WDXRF spectrometer (Axios 2005, PANalytical, Netherlands) was used for quantitative analysis of Catha edulis plant samples. The WDXRF allowed rapid and accurate elemental analysis technique and was able to deal with the different type of samples in the form of solids, fused beads, pressed or loose powder and liquid samples. The X-ray tube in the present WDXRF spectrometer had Rh anode and operated at a maximum power of 4 kW and maximum current of 160 mA. To obtain high-resolution spectra, five dispersive crystals were used, LiF200, PE curved, PXI, LiF220 and Ge curved. To recognize all the elements in the present plant samples, the characteristic radiation of the major, minor and trace elements were recorded in ten different scans. Each scan covers a certain number of the expected elements and the peak areas of the characteristic radiation were estimated. Using the measured intensities of the characteristic radiation, a standard-less analysis program (IQ+ software) based on the fundamental parameters approach was used [19-22].

III. RESULTS AND DISCUSSION

To our knowledge, the natural radioactivity of Catha edulis was never discussed in the literature before. In order to illustrate the radioactivity of Catha edulis and tobacco plant samples, the quantitative elemental analysis of all elements were determined by using Wavelength dispersive X-ray fluorescence spectrometry (WDXRF). Twenty two elements were quantitatively determined namely; Al, Ba, Bi, Br, Ca, Cl, Cu, Fe, K, Mg, Mn, Na, Ni, P, Rb, S, Si, Sr, Ti, Y, Zn and Zr. Figure 3 depicts an example of some scans of the characteristic radiation of Catha edulis plants (leaves and stalks). The characteristic radiations of these elements were recognized at different scans based on the different optimal condition such as the applied power of the X-ray tube, dispersive crystal, detectors, collimators… etc. More details about the quantitative analysis of Catha edulis as well as other related plants using wavelength dispersive X-ray fluorescence can be found in our previous work [19, 20]. In the case of tobacco, the results of the quantitative elemental analysis of Oyewale et al [23] were considered. More than 50 elements were determined by Energy dispersive x-ray fluorescence (EDXRF) analysis as well as other related methods [24, 25]. Based on the quantitative analysis results of Catha edulis and tobacco plants, some toxic, radioactive and heavy metals were detected such as; As, Cr, Zn, Fe, Cd, Cu, Pb, Cr, Zn, Hg, ^{226}Ra, ^{214}Bi, ^{238}U series, ^{228}Ac, ^{228}Ra, ^{232}Th series, ^{40}K, ^{137}Cs, ^{210}Po. It is expected that, the heavy use of Catha edulis and tobacco may increase the concentration of these elements inside the human body and consequently increase the incidence of many diseases, especially oral and lung cancer [26-30]. Therefore, these elements seem to be very dangerous and can cause a severe problem on human health.

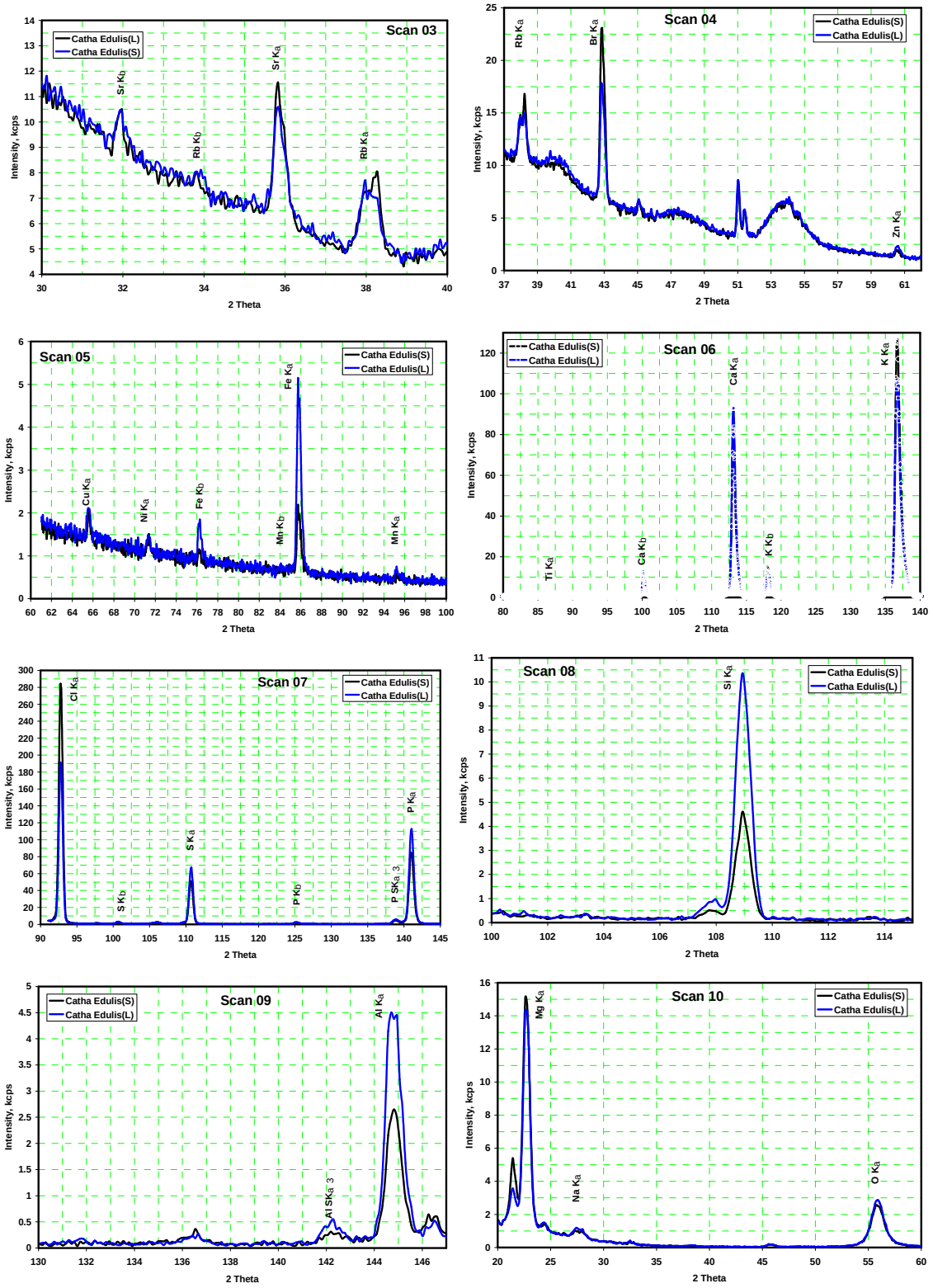

Figure 3, Wavelength dispersive x-ray fluorescence spectrum of Catha edulis plant (leaves and stalks).

The concentrations of the natural radioactivity of ^{226}Ra, ^{238}U, ^{232}Th, and ^{40}K in Catha edulis and tobacco samples were determined. Table 1 illustrates the radionuclide concentration in the sample under investigation. As shown from Table 1, the average concentrations of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in Catha edulis were 59.5±2.40, 0.285±0.05, 50.25±4.88 and 687±38.18 Bq/kg respectively, whereas the average concentrations of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in tobacco plants were 71.0±2.26, 0.81±0.04, 71.35±8.84 and 1126.5±50.20 Bq/kg respectively. It is clear that, the concentrations of the natural radioactivity of the Catha edulis plants are lower than the concentrations found in tobacco plants. This could be an indication that, the risk of the radioactive

materials in tobacco is greater than that risk in Catha edulis. However, the combination between chewing Catha edulis and smoking tobacco at the same time increases the risk on the human health and they may cause further serious effect on living cells of the human body. The severity and risk of heavy, toxic and radioactive elements of tobacco and Catha edulis appear in the long term, which has been observed among Yemeni people during the past years [35, 36]. Finally, one could speculate that, the influence of smoking of tobacco and chewing Catha edulis simultaneously will increase the accumulation of heavy, toxic and radioactive elements inside the living cells of the body. Consequently, the influence of this behavior is clearly proportional with time. For usage the Catha eduls and tobacco continuously for long time, the remarkable influence on Yemeni's heath was observed and this behavior could be one of the main reasons of the oral and lung cancer [31-36].

Table 1. Radionuclide concentration (Bq/kg) of the Catha edulis and tobacco plants grown in Yemen.

Sample	Activity concentration, Bq/kg			
	^{226}Ra	^{238}U	^{232}Th	^{40}K
Catha edulis 1	57.8	0.32	46.8	714
Catha edulis 2	61.2	0.25	53.7	660
Tobacco 01	69.4	0.78	65.1	1162
Tobacco 02	72.6	0.84	77.6	1091

IV. CONCLUSION

Based on the analytical results of X-ray fluorescence of Catha edulis and tobacco plant samples, heavy, toxic and radioactive elements were quantitatively demonstrated. The higher abundance of these elements in the present plant samples increases the intake radiation dose in the human body, which consequently can cause oral and lung cancer over the long term. The natural distribution the radioactivity of the Catha edulis and tobacco plant samples are higher than the normal distribution of radioactivity without samples. In addition, the Catha edulis plant seems to have more radioactivities when compared with tobacco. It was found that, there are many diseases arising from the radioactivity of such plants and some of them have carcinogenic effects. The issue of chewing Catha edulis and smoking tobacco at the same time increases the risk and should have more attention.

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