Radioactivity in Tobacco plants and Elemental Analysis using ICAP-AES Technique

Pooja Chauhan

Baddi university of Emerging Sciences and Technology Baddi-173205, Solan (H.P) India

****Corresponding author: Pooja Chauhan***

Abstract

Tobacco is the most significant cause of lung cancer and radon is more dangerous for smokers than non-smokers. In the present study, alpha radioactivity is measured in tobacco leaves taken from plants grown using different types of chemical fertilizers in varying amounts has been made. For these measurements we used α-sensitive LR-115 type II plastic track detectors. The alpha track densities were found to vary with nature of fertilizers added to the soil and an increase was also observed with time. The inductively coupled argon plasma atomic emission spectrometry was used for the analysis of elements present in tobacco samples.

Keywords: *Alpha Radioactivity, Nicotina tabacum, SSNTDs, Elements*

Corresponding author: pooja.chauhan ,Phone: +918607487764

1. Introduction

Tobacco smoke is responsible for majority of lung cancers where cigarette smoking is common (Alberg and Samet, 2003). Almost 90% of pulmonary cancer death cases can be assigned to smoking, the carcinogenic effect of which is well known (CDC, 2000). Botanically, tobacco is one of the family *Solanaceae*, genus *Nicotiana*. Tobacco is generally used in two modes, smoking and chewing (nonsmoking), though a third mode called snuff tobacco is also prevalent in many countries (Garg et al., 2012). Many recent studies have established the presence of natural radionuclides of the uranium and thorium series in fresh as well as dry tobacco leaves but in an amount exceeding that found normally in general food stuffs for human consumption and hence, cigarette smoking is one of the practices of radiological concern (Kilthau, 1996; Peres and Hiromoto, 2002).

Polonium-210 (which has a physical half-life time of 138 days) is a member of the natural uranium-238 series and one of the relatively long-lived radionuclides of radon decay products. It is an alpha-emitting radionuclide and is present in trace amounts in most plants and foodstuffs as well as in human tissues (Batarekh and Teherani, 1987). Approximately 84% of the alpha activity of plants is due to ^{210}Po (Mayneord et al., 1960). The accumulation of heavy metals in environmental samples such assoils and sediments causes a potential risk to human health due to the transfer of these elements in aquatic media, their uptake by plants andtheir subsequent introduction into the food chain (Alonso Castillo et al., 2011). Heavy metals like Cu, Cd, Ni, Pb, Zn are major environmental pollutants, potentially considered to be toxic, mutagenic and carcinogenic though a few of them are essential elements for vital metabolic processes (Rama Devi and Prasad, 1998).

In the present work, the estimation of alpha radioactivity in tobacco plants grown using various fertilizers in different amounts before the plantation of the seedlings, has been made and reported. Tobacco samples were analyzed using inductively coupled argon plasma atomic emission spectrometer to determine concentrations of elements present in them.

2. Experimental Details

2.1. Control growth of tobacco plants using different fertilizers

For the measurement of alpha radioactivity in tobacco leaves LR-115 Type-II nuclear track detectors have been used. These are widely applied for the detection of alpha particles because of low background noise and better contrast. Also these have low sensitivity to beta and gamma radiations and hence suitable for detection of alpha particles in mixed radiation fields. In the present control study, the tobacco plants were grown by planting the seeds in earthen pots having equal amounts of same type of soil. 20 gm of fertilizers like DAP (Diammonium Phosphate), NPK (nitrogen, phosphorus and potassium), potash fertilizer (PF), single super phosphate (SSP), zinc sulphate ($ZnSO_4$) were added to the soil just before the plantation of tobacco plants in the pots and then samples of healthy leaves were collected after regular internal of time from pots of tobacco plants, dried in an oven at a temperature of 40 °C in Laboratory. Finally, LR-115 detectors were sandwiched of the same size using cello tape tightly in order to record the tracks of alpha radiations emitted from both upper and bottom faces of the leaves. Then the samples were etched in etching bath using sodium hydroxide solution at a temperature of 60^0 C for 90 minutes time for developing the registered tracks. The removed layer was first pre sparked at 900 V and counted at 500 V twice.

2.2. Sample preparation and analysis of elements present in tobacco samples using ICAP-AES

In wet ashing for the digestion of plants, 0.4g of each sieved sample was placed in to conical flask; 10ml of diacid (HNO_3 and $HCLO_4$ in 3:1 ratio) was added to these samples. The mixture was heated below boiling for 17-20 min. On the appearance of brown vapours, the samples were heated for until a white of grey ash residue was obtained and then solution was cooled to room temperature. With the addition of double distilled water to each residue and filtered using Whatman No. 42 filter paper. Finally, filtrate were collected in volumetric flask and made up of volume of 50ml. The multi elemental analysis of samples was performed using inductively coupled argon plasma atomic emission spectrometer.

For the measurement for different elemental present in tobacco samples, we use an inductively coupled argon plasma atomic emission spectrometer iCAP-6300 Duo (Thermo Scientific, United Kingdom). The entire system controlled with iTeva software.The optimum conditions selected was 1.1-1.3 KW radio frequency power, 0.50 L/minas nebulizer flow rate. The detector Charge injector device (CID) was used in iCAP. The torch consists of three concentric quartz tubes through which argon flows. In this instrument, spectrometer is a multi-component part containing mirrors and prisms used to separate the specific wavelength of interest. The analytical performance of this is demonstrated by improved detection limits, enhanced linearity, superior long-term stability and high resolution images. This instrument operates sequentially with both radial and axial torch configurations.

3. Results and discussion

3.1. Alpha track density in tobacco plants

For the present control study on tobacco plants grown using different fertilizers, alpha track densities for various samples taken as leaves collected after 30 days of the plantation was measured as shown in Table 1. For the leaves collected from the plants after 30 days of plantation in Diammonium Phosphate (DAP), nitrogen, phosphorus and potassium (NPK), potash fertilizer (PF), single super phosphate (SSP) and zinc sulphate ($ZnSO_4$) fertilized pots. The alpha track densities (Tcm^{-2}) were measured on the top and bottom faces of the leaves of tobacco plants varied from 180-250, 264-298, 313-396, 239-297, 248-297 with track density 3.5, 5.8, 4.6, 4.5 and 4.4 Tcm^{-2} respectively as shown in Table 1.The variation in alpha track densities at the top and bottom faces of the leaves was found to be there for the same leaf.

3.2. Elemental analysis using ICAP-AES

The elemental content (Cd, Cu, Ni, Pb, Zn, As, Mn and Cr) of tobacco plant samples were determined by inductively coupled argon plasma-atomic emission spectrometer (ICAP-AES) and analytical results are shown in Table 2. Zinc and copper are essential elements in plant function with low concentrations and aid in plant metabolism photosynthesis and activator of several enzymes. It has been reported that phosphate fertilizers in soil can increase the amount of cadmium available for plant uptake. Cadmium contents in all tobacco samples (TOB1, TOB2, TOB3, TOB4 and TOB5) varied from (0.36-1.22 mg/Kg). The heavy metal content in tobacco is variable and depends on the conditions under which tobacco plant is grown and mostly on the composition and properties of the soil. Copper (Cu) in all tobacco samples (TOB1, TOB2, TOB3, TOB4 and TOB5) ranging from (16.2-29.6 mg/Kg)**,** nickel (Ni) with range of (9.55-14.69 mg/Kg)**,** lead (Pb) (2.67-4.0 mg/Kg), and value for zinc (Zn) was with range of (71.35-89.9 mg/Kg) metals content in tobacco sample was also measured.

4. Conclusion

From the present investigation we can conclude that:

The alpha track density was found to be higher on the bottom face as compared to that on the upper face which may be due to the presence of large number of trichomes at the lower face to which dust particle from environment with the radon daughter attached, get stuck. Tobacco plants are main source of trace metals which are transferred from roots to stems and leaves, attached on the surface of leaves.

Acknowledgments

The authors are thankful to UGC, New Delhi for providing financial assistance in the terms of major research project. The ICAP-AES facility provided by PAU, Ludhiana (Punjab) for elemental analysis is also thankfully acknowledged.

References

[1] Alberg, A.J., & Samet, J.M. (2003). Epidemiology of lung cancer. *Chest.* 123, 21-49.

[2] CDC (2000). Centers for disease control and prevention. Reducing Tobacco Use: A Report of The Surgeon General. US Government Printing Office, Washington, S/N 017-001-00544-4.

[3] Garg, A.N., Choudhury, R.P., Acharya, R., & Reddy, A.V.R. (2012). Determination of minor, trace and toxic elements in chewing tobacco products by instrumental neutron activation analysis and determination of glutamic acid. *Journal of Radioanalytical and nuclear Chemistry*. DOI 10. 1007/s10967-012-1845-4.

[4] Kilthau, G.F. (1996). Cancer risk in relation to radioactivity in tobacco. *Radiologic Technology*. 67(3), 217-222.

[5] Peres, A.C., & Hiromoto, G. (2002). Evaluation of ^{210}Pb and ^{210}Po in cigarette tobacco produced in Brazil. *Journal of Environmental Radioactivity*. 62, 115-119.

[6] Batarekh, K., & Teherani, D.K. (1987). Determination of polonium-210 in cigarettes from Syria. *Journal of Radioanalytical Nuclear Chemistry Letters.* 117 (2), 75–80.

[7] Mayneord, W.V., Turner, R.C., & Radley, S.M. (1960). Alpha activity of certain botanical materials. *Nature.* 187, 208-212.

[8] Alonso Castillo, M.L., Vereda Alonso, E., Siles Cordero, M.T., Cano Pavón, J.M., & García de Torres, A. (2011). Fractionation of heavy metals in sediment by using microwave assisted sequential extraction procedure and determination by inductively coupled plasma mass spectrometry. *Microchemical Journal.* 98, 234-239.

[9] Rama Devi, S., & Prasad, M.N.V. (1998). Copper toxicity in Ceratophyllum demuersum L. (Coontail), a free floating macrophyte: Response of antioxidant enzymes and antioxidants. *Plant Science.* 138, 157-165.

Table 1. Alpha track densities measured in the leaves of tobacco plants after 30 days of plantation

Sr. No.	Fertilizer Used	Tracks/cm^2 on Leaves		AM±SE*	Tcm^{-2}d^{-1}
		Top face	Bottom face		
1.	DAP-1	180	250	214±33	3.5
6.	NPK-3	264	298	280±16	4.6
9.	PF-3	313	396	355±41	5.8
12.	SSP-3	232	297	266±32	4.5
15.	$ZnSO_4$-3	248	297	271±24	4.4

*AM= Arithmetic Mean, SE= Standard error (σ/ √ N), where σ is Standard deviation and N is the no. of observations

DAP= Diammonium Phosphate, NPK = Nitrogen, Phosphorous, and Potassium, PF= Potash Fertilizer, SSP= single super phosphate, $ZnSO_4$ =zinc sulphate

Table 2. The contents of elements (mg/Kg) in different tobacco samples using ICAP-AES

Element	**TOB1**	**TOB2**	**TOB3**	**TOB4**	**TOB5**
Cd	1.07	1.22	0.36	0.61	1.05
Cu	16.2	20.7	29.6	18.9	25.5
Ni	14.69	14.03	10.74	9.55	12.3
Pb	2.67	3.88	3.35	4.0	3.88
Zn	89.9	86.8	76.49	71.35	82.2

TOB1 = Tobacco plant fertilized with Diammonium Phosphate, TOB2 = Tobacco plant fertilized with Nitrogen, Phosphorous, and Potassium, TOB3 = Tobacco plant fertilized with Potash Fertilizer, TOB4 = Tobacco plant fertilized with single super phosphate TOB5 = Tobacco plant fertilized with zinc sulphate