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Assessment of Radionuclides Present in Atmospheric Aerosol in Dar Es Salaam, Tanzania by using Gamma-ray Spectrometry

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ABSTRACT

The presence of Natural Occurring Radioactive Materials (NORMs) and artificial radionuclides in the atmosphere is of special interest to the public health. The fallout of artificial radionuclides from nuclear activities and emissions of NORMs present in the earth's crust can access the atmosphere. Radionuclides detections in the atmosphere allows scientists to be aware on the behavior of radionuclides and their effect to human health. In this study, activity concentrations of naturally-occurring radionuclides Beryllium-7 (^{7}Be) and Lead-212F (^{212F}Pb) in the atmosphere together with meteorological data collected in IMS radionuclides station TZP64 located in Dar es Salaam, Tanzania were analyzed . Activity concentrations of ^{212F} Pb and ^{7}Be from 2008 to 2018 were found to be within the range of 38466$\pm$ 0.7444 µBq/m^3 to 24458$\pm$0.8681 µBq/m^3 and 4786$\pm$1.172µBq/m^3 to 3588 $\pm$ 1.238 µBq/m^3 respectively. ^{212F} Pb and ^{7}Be show distinct annual trends, suggesting that atmospheric conditions affect both radionuclides differently and independently.

INTRODUCTION

The atmosphere is an important part of our environment in which we live in. It contains particulate matter of different origin. Among them is radionuclide originating from natural and anthropogenic sources. These are always in dynamic process and they are quickly diffused to short and long distances when attached to aerosols. The long term monitoring of radioactivity in the atmosphere is therefore very important to the evaluation of the impact and effect caused to the population. The Natural occurring radionuclide includes ^{7}Be, ^{212F} Pb (^{212}Pb, ^{212}Bi and ^{212}Po), ^{210}Pb, ^{40}K and ^{214}Bi and are commonly detected at IMS The Radionuclide station (TZP64) located in Dar es Salaam, Tanzania. ^{7}Be and ^{212F} Pb the two natural radionuclide which are measured on daily basis in all IMS stations. These radionuclides are the major contributor to counts of gamma spectra measured and hence have a direct effect to detection capability for CTBT relevant radionuclide (Werzi 2010).

^{212F} Pb are progenies of ^{220}Rn which is the gaseous radioactive product in the thorium decay chain. It originates from coastal and island sites, soil and in the cement industries. These may enter the atmosphere where they are distributed by meteorological process (Singh 2005). The radon decay products are radioactive isotopes of polonium, bismuth, lead and thallium which are easily attached to existing aerosol particles in the atmosphere. ^{7}Be is a natural radionuclide ($T_{1/2}$ = 53.3 days) originating from the interaction of galactic cosmic rays with atoms constituting the atmosphere. It forms aerosol particles in sub micron size range with activity mean diameter of 0.5-0.7 µm (Ioannidou et al.2005) and removed in the atmosphere by dry and wet deposition.

Several studies have been conducted in local and regional scale to show correlation between temporal changes of these radionuclide and meteorological parameters mainly, precipitation, humidity, air temperature, wind direction and wind speed. The results show that rain and humidity conditions may cause the decrease of ^{7}Be activity concentration in Inter Tropical Convergence Zone (ITCZ) (Kusmierczyk-Michulec et al. 2015).This study investigates the influence of meteorological parameters to both ^{7}Be and ^{212F} Pb as collected in Dar es Salaam.

MATERIALS AND METHODS

The aerosols samples of diameters 0.2 µm and above were collected on the roof of Physics Department of the University of Dar es Salaam using High volume air sampler with a flow rate ranged from 800 to 850 m^3/hr. All radionuclide were left for 24 hours for all short lived radionuclide to decay so as to improve detection limit. The activity concentration of ^{7}Be, ^{212F}Pb and other aerosol-bound nuclides were measured using Gamma-Ray spectrometry based on the CTBTO Standard Operating Procedure of 2016. ^{7}Be and ^{212F}Pb data series were analyzed together with the corresponding meteorological parameters. Linear regression analysis and Pearson's Correlation coefficient was employed to examine relative contribution of air temperature, relative humidity, wind speed and precipitation of variability of ^{7}Be and ^{212F}Pb concentrations.

RESULTS AND DISCUSSION

Trends of the activity concentration of ^{212F} Pb and ^{7}Be before and after background subtraction

The background is not static, it varies with time and space and mostly depends on weather conditions including Power shut down. Certainly there were several contributions from the background and blank in the sample if not subtracted because it will provide unwanted additional activity. Normally the presence of background affects the detection limits of very low activity cases.

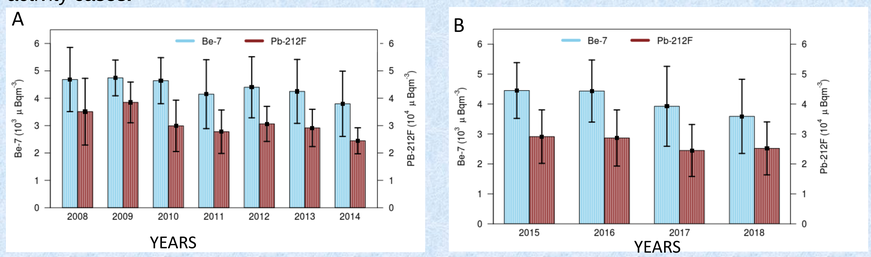

Figure 1 A). trend of ^{212F} Pb and ^{7}Be before background subtraction B). Trend of ^{212F} Pb and ^{7}Be after background subtraction.

The periodic pattern of ^{212F} Pb and ^{7}Be median monthly concentrations were observed in the atmosphere for 11 years (2008 to 2018). The two radionuclides were not affected by background subtraction. For the analysis, the year 2015 has been selected. The twelve month data set in Fig.2 below have ^{212F} Pb activity concentration value higher compered to ^{7}Be.

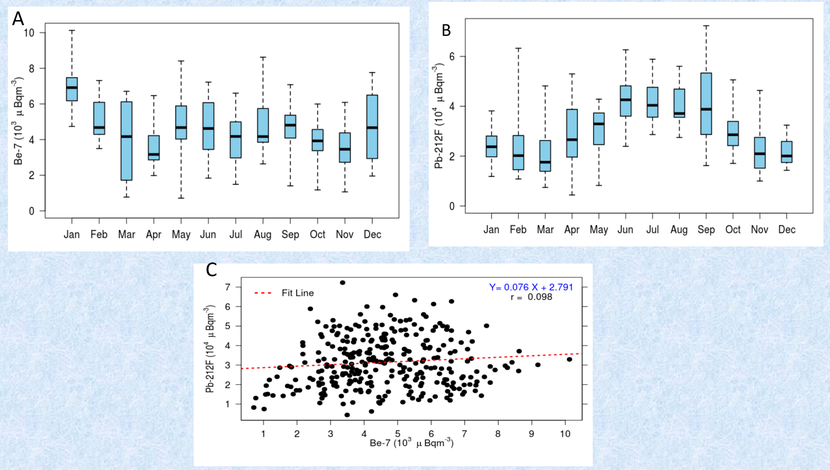

Figure 2 (A and B). Boxplots with Whiskers from minimum to maximum, representing monthly variations of activity concentration of ^{212F} Pb and ^{7}Be over 2015.The upper and lower edge of the box represent the First and the Third Quartile. (C) correlation between the activity concentration of ^{212F} Pb and ^{7}Be over 2015

The analyzed results of ^{212F} Pb and ^{7}Be recorded during 2015 shows that the two radionuclides have different sources of origin. This can be speculated from Fig(2C) where the graph plots of the two show no correlation between them.

Influence of Meteorological Parameters to ^{212F} Pb and ^{7}Be

From fig 2(A). ^{212F} Pb has a high concentration on the month of June 2015 which is in dry season and high concentration of ^{7}Be in January 2015 which is in a semi dry season. Their variation was influenced by meteorological parameters including rainfall(precipitation), humidity, air temperature and wind speed.

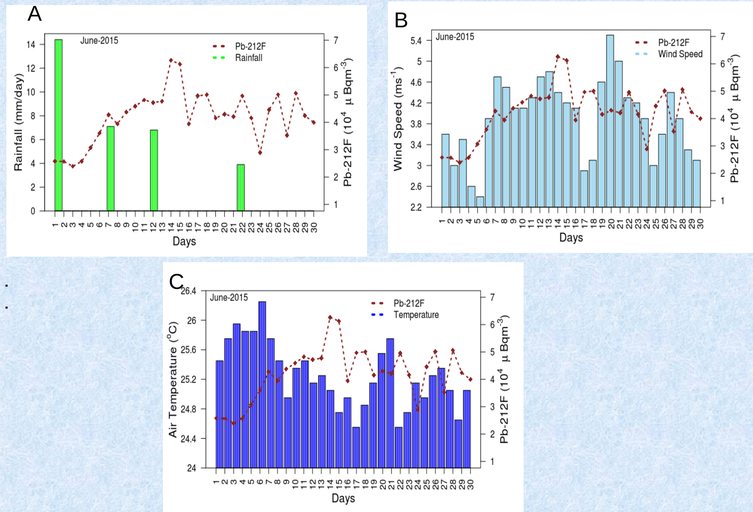

Figure 3. (A to C)Daily changes of ^{212F} Pb with the daily rainfall, wind speed and air temperature.

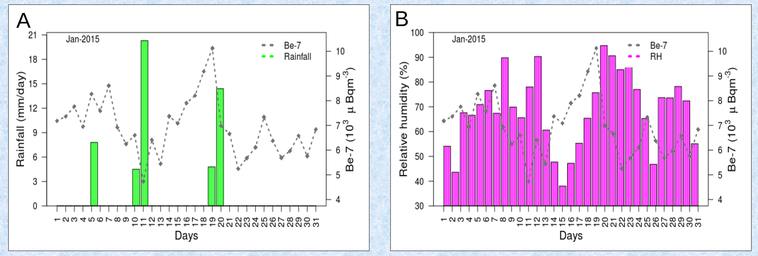

Figure 4. (A-B) Daily changes of . ^{7}Be with the daily precipitation and Relative humidity

The Fig. 3. (A to C) and Fig. 4. (A-B) show the variation of ^{212F} Pb and ^{7}Be activity concentration with the daily values of precipitation, air temperature humidity and wind speed which have correlation.

CONCLUSION

The study has presented the assessment of radionuclides ^{212F} Pb and ^{7}Be in atmospheric aerosols as collected at IMS CTBTO station in Dar es Salaam, Tanzania. The activity concentrations of ^{212F} Pb and ^{7}Be from 2008 to 2018 were found to be within the range of 38466$\pm$ 0.7444 µBq/m^3 to 24458$\pm$0.8681 µBq/m^3 and 4786$\pm$1.172µBq/m^3 to 3588 $\pm$ 1.238 µBq/m^3 respectively. The results show the two radionuclide ^{212F} Pb and ^{7}Be have different origin. ^{7}Be appears to have high concentration during January while ^{212F} Pb during June 2015 which were dry seasons in Dar es Salaam. It was observed that the removal of ^{7}Be increases with air humidity and increasing Rainfall. Thus rainfall and humidity effect aerosol deposition. The ^{212F} Pb activity concentration decreases with increasing temperature in June 2015. It is also increases with the increasing wind speed. This agrees with previous literature results. Further studies will be conducted in all years to assess the influence of meteorological parameters on the identified radionuclides in IMS radionuclides station TZP64,located in Dar es Salaam, Tanzania

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