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# INVESTIGATION OF ENVIRONMENTAL POLLUTION IMPACTS ON RADON LEVELS AND ELEMENTAL CONTENTS IN AGRICULTURAL SOIL SAMPLES FROM MYINGYAN TOWNSHIP

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## Abstract

Environmental pollution impact is the most important issue of our time. Soil and water pollution, in particular, have historically impacted on food safety which represents an important threat to human health. In this research work, twelve agricultural soil samples collected from the four places of agricultural area of Photokephyu Village in Myingyan Township were analyzed scientifically for environmental pollution protection purpose. To estimation of the nuclear pollution, especially radon concentration, surface and mass exhalation rates, and effective dose were carried out by Solid State Nuclear Track Detection. The soil samples were determined by Energy Dispersive X-Ray Fluorescence Method for elemental concentrations quantitatively. The measurement results radon level found in this study were below the action level recommended by the ICRP. In EDXRF results, the toxic elements were not found in the samples. Results reveal that there is no significant public health risk from radon and elemental concentrations in the study region. The present investigation is useful from the health and environmental point of view.

**Keywords**: SSNTD, EDXRF, agricultural soil, environmental pollution, health risk

## Introduction

Radiation is a natural part of the environment in which we live. All people receive exposure from naturally occurring radioactivity in soil, water, air and food. The largest fraction of the natural radiation exposure we receive comes from a radioactive gas, radon and its daughter. When radium decays, a radon and an alpha particle produced then the radon atom moved into an adjacent crystal by recoil effect from ejected α-particle. The rate at which radon escapes from soil into the surrounding air is known as radon exhalation rate of the soil. Solid state nuclear track detectors, known as passive method, are widely used for radon measurements. The CR-39 detector is very sensitive

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for the detection of α-particles, particularly, emitted by radon and their progeny. The metal elements are naturally introduced in the environment through rocks harshness, and also by a variety of human activities through industrials, cattle raising and agricultural. Fe, Zn, Cu and Mn are essential micronutrients to the growing of aquatic organisms. While metals such Cd, Pb, and Hg are not necessary to the growing of these organisms, they are toxic even in trace amounts. However, above the allowed limit of each element, and all metals have a high degree of toxicity in the environment. EDXRF is an analytical method for qualitative as well as quantitative determination of elements in a sample, independent of their chemical forms. This study was undertaken for the purpose of estimating the radon concentration, radon exhalation rates and annual effective dose measurements in agricultural soil samples from Photokephyu Village in Myingyan Township, by using CR-39 SSNTDs. This measurement results were compared with the limit of ICRP Recommendation values. To analyze the elements contained in these samples, the energy dispersive x-ray fluorescence (EDXRF) system (Shimadzu EDX-720 spectrometer) was used. To estimate the radiological hazard associated with them to the general population living for agriculture in the study areas of Myingyan Township.

## Materials and Methods

### Sample Collection and Processing

Twelve soil samples were collected from surface soil, depth 15 cm and depth 30 cm at four places of agricultural studied areas in Photokephyu Village (Myingyan Township). The collected soil samples were dried at room temperature for a week. After drying, the samples were crushed to a fine powder and sieved through a small mesh size to remove the larger grains size and render them more homogenous. The map and photograph of the studied area is shown in Figure1. The list of sample and description of sample location are shown in Table1.


**Figure 1:** The map and photograph of the studied area in Myingyan Township

**Table 1:The List of Sample and Description of Collected Sample Location**

| **Sample Name** | **Depth of Collected Sample** | **Location of Collected Sample in Studied Area** |
|---|---|---|
| $S_{11}$ | Surface layer of soil | east |
| $S_{12}$ | 15 cm | |
| $S_{13}$ | 30 cm | |
| $S_{21}$ | Surface layer of soil | west |
| $S_{22}$ | 15 cm | |
| $S_{23}$ | 30 cm | |
| $S_{31}$ | Surface layer of soil | south |
| $S_{32}$ | 15 cm | |
| $S_{33}$ | 30 cm | |
| $S_{41}$ | Surface layer of soil | north |
| $S_{42}$ | 15 cm | |
| $S_{43}$ | 30 cm | |

**Experimental Details of SSNTD Measurements**

In the present investigation, "Sealed Can Technique" was used to study radon concentration, radon exhalation rates and annual effective dose.

Dried and sieved sample (100 g) was placed at the bottom of a cylindrical sealed Can of height 5.5 cm and diameter 7.5 cm. The schematic diagram and photograph of the Can technique are shown in Figure 2.


**Figure 2:** The schematic diagram and photograph of the Can Technique

Initially, the mouth of the cylindrical Can was sealed without CR-39 plastic track detector for one month so as to acquire equilibrium between radium and radon members. The CR-39 detectors were square in shape, 1cm × 1cm in size. The CR-39 is a small piece of plastic that is sensitive to tracks of highly ionizing particles such as alpha particles. Thereafter, the cover was replaced quickly by a cover fitted with CR-39 detector at the top inner surface in such a way that the sensitive surface of the detector faced the sample. The detectors were exposed for a period of about 100 days. In sealed Can technique, the material of interest has enclosed in a ‘cylindrical plastic Can’ and sealed for a period of three weeks in order to get secular equilibrium between radium and radon.

After the 100 days period of exposure, the CR-39 detector samples were chemically treated by etching using 6.25 N solution of NaOH at temperature of 70°C, for 6 hours. The temperature was kept constant with an accuracy of ±1°C. At the end of etching process, the detectors were washed thoroughly with water and then air-dried. The number of alpha tracks of each detector was counted visually using optical microscope with a magnification of 400X. Then, the track density of detector samples were obtained by taking the average of twenty fifth views in the microscope. The area of one Field of

View (FoV) is 0.00332 $cm^2$. The photograph of optical microscope is shown in Figure 3.

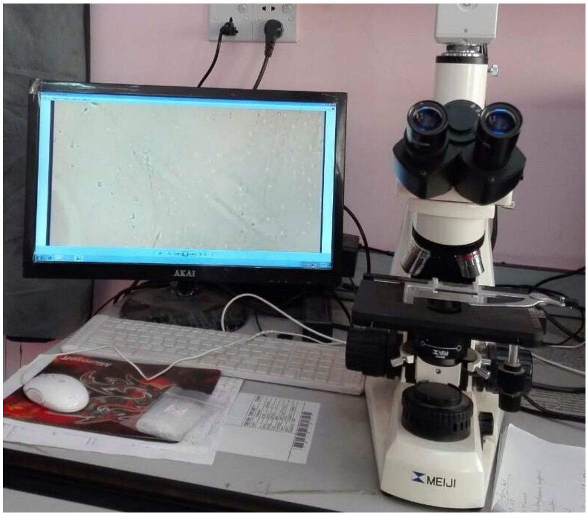


**Figure 3:** The photograph of optical microscope

The alpha track density of each detector was calculated as the relation:

$$\text{Alpha Track Density} = \frac{\text{Average number of alpha tracks counted in all fields of view}}{\text{Counted area (one field of view)}}$$

The standard error in the average number of alpha track counts and alpha track densities were calculated as:

$$\text{Standard Deviation } (\sigma) = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}{N}}, \qquad \text{Standard Error} = \frac{\sigma}{\sqrt{N}}$$

The radon concentration was found by using this formula:

$$C_{Rn} = \frac{\rho}{KT}$$

Where $\rho$ is track density (track /$cm^2$), K is the calibration factor (0.23 tracks $cm^{-2}$ $d^{-1}$ per Bq $m^{-3}$), and T is the exposure time (100 days).

Exhalation rates in terms of surface and mass were calculated from the following equations.

$$E_x = \frac{CV\lambda}{A\left[T+\lambda^{-1}\left\{e^{-\lambda T}-1\right\}\right]}$$

$$E_M = \frac{CV\lambda}{M\left[T+\lambda^{-1}\left\{e^{-\lambda T}-1\right\}\right]}$$

Where, C is integrated radon exposure concentration ($Bqm^{-3}$), V is volume of Can (0.00024 $m^3$), T is exposure time (100 days), M is mass of the sample in Can (0.1kg), $\lambda$ is the decay constant for radon (0.1825 $day^{-1}$) and A is area of the (0.0044 $m^2$).

According to the UNSCEAR (2000) report, annual mean effective dose H is estimated using the following equation:

$$H = C \times E \times F \times T \times D$$

Where C stands for the radon concentration (Bq $m^{-3}$), E is the equilibrium factor for indoor that is set as 0.36, O is the occupancy factor taken as 0.8, T is time in hours in a year (8760 $hy^{-1}$) and D is the dose conversion factor ($9\times10^{-6}$ m $Sv^{-1}$ (Bq $m^{-3})^{-1}$ $h^{-1}$).

## Experimental Details of EDXRF Technique

Each one sample was pressed with hydraulic press weighing 5 tons a pellet with a diameter in 2.5 cm. Each soil samples was analyzed using Shimadzu EDX-720 (Japan) spectrometer. The Shimadzu EDX-720 detects these x-rays and quantitatively determines which elements are present in the material. The Shimadzu EDX-720 is an Energy Dispersive XRF system, kwon as EDXRF. This indicates that the x-rays are detected using a semiconductor detector, which permits multi-element, simultaneous analysis.

EDX-720 spectrometer system consists of an x-ray generator and x-ray tube, a detector, a sample chamber, measuring electronics system and personal computer. Figure 4 illustrates the functional diagram and photograph of EDX-720 spectrometer system. The Shimadzu EDX-720 is equipped with high level Fundamental Parameter (FP) software for the determination of organic materials using scattered x-rays in addition to the characteristic lines. This spectrometer can operate either under normal air pressure or in vacuum. The powder sample pellets were placed in the samples chamber which can measure sixteen samples at on time.


**Figure 4:** The functional diagram and photograph of EDX-720 spectrometer system

The EDX-720 spectrometer was x-rays tube excited system with Rh target at its optimum conditions of (50 kV, 25 μA). A high resolution semiconductor detector, Si (Li) detector, was used in the system. The detector can be stored at room temperature but the working temperature of the detector must be kept at liquid nitrogen (-170˚C). The detector has an area of 10 $mm^2$. The resolution FWHM of the Si (Li) detector system was (<155 eV). Each pellet was run for 99 seconds and the x-ray spectra were analyzed in IBM PC using EDX-720 software. The software utilizes the personal computer functions to transfer data to hard disk.

## Results and Discussion

### Determination of Radon levels in Soil Samples

The photograph of the alpha tracks on the detector samples ($S_{43}$) is shown in Figure 5. The measurement results of radon levels in soil samples from agricultural studied area are shown in Table 2. Figure 6 shows the radon concentration in agricultural soil samples from different locations. The variation of radon surface and mass exhalation rates and annual effective dose in different samples are shown in Figure 7. The radon concentrations ranging from 6.77 ± 3.39 Bq $m^{-3}$ to 84.31 ± 15.66 Bq $m^{-3}$ with an average value of 41.55 ± 8.32 Bq $m^{-3}$. The surface exhalation rate has been found to vary from 0.07 ± 0.04 to 0.88 ± 0.16Bq $m^{-2}$ $day^{-1}$ with an average value of 0.43 ± 0.09 Bq $m^{-2}$ $day^{-1}$. The mass exhalation rate has been found to vary 0.003 ± 0.002 to 0.039 ± 0.007 Bq $kg^{-1}$ $day^{-1}$ with an average value of 0.019 ± 0.004 Bq $kg^{-1}day^{-1}$. The annual effective dose varies from 0.15 to 1.91 m Sv $y^{-1}$ with an average value of 0.94 m Sv $y^{-1}$.

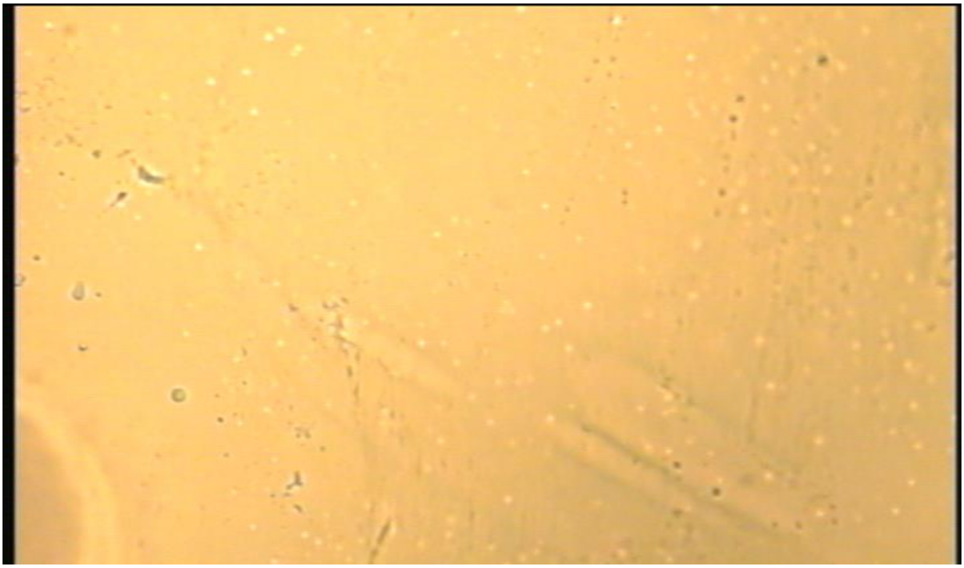

**Figure 5:** The photograph of the alpha tracks on the detector samples ($S_{43}$)

**Table 3: The measurement results of radon levels in soil samples from agricultural studied area**

| Sample No. | Alpha Track Density (tracks $cm^{-2}$) | Radon Concentration (Bq $m^{-3}$) | Radon surface exhalation rate (Bq $m^{-2}$ $day^{-1}$) | Radon mass exhalation rate ( Bq $kg^{-1}$ $day^{-1}$) | Annual Effective Dose (m Sv $yr^{-1}$) |
|---|---|---|---|---|---|
| $S_{11}$ | 759.04 ± 250.08 | 32.79 ± 10.80 | 0.34 ± 0.11 | 0.015 ± 0.005 | 0.74 |
| $S_{12}$ | 915.66 ± 188.82 | 39.55 ± 8.16 | 0.41 ± 0.09 | 0.018 ± 0.004 | 0.89 |
| $S_{13}$ | 1686.75 ± 252.42 | 72.86 ± 10.90 | 0.76 ± 0.11 | 0.034 ± 0.005 | 1.65 |
| $S_{21}$ | 156.63 ± 78.44 | 6.77 ± 3.39 | 0.07 ± 0.04 | 0.003 ± 0.002 | 0.15 |
| $S_{22}$ | 746.99 ± 175.09 | 32.27 ± 7.56 | 0.34 ± 0.08 | 0.015 ± 0.003 | 0.73 |
| $S_{23}$ | 1024.10 ± 296.80 | 44.24 ± 12.82 | 0.46 ± 0.13 | 0.020 ± 0.006 | 1.00 |
| $S_{31}$ | 686.75 ± 171.79 | 29.67 ± 7.42 | 0.31 ± 0.08 | 0.014 ± 0.003 | 0.67 |
| $S_{32}$ | 831.33 ± 78.26 | 35.91 ± 3.38 | 0.38 ± 0.04 | 0.017 ± 0.002 | 0.82 |
| $S_{33}$ | 1096.39 ± 211.82 | 47.36 ± 9.15 | 0.50 ± 0.10 | 0.022 ± 0.004 | 1.08 |
| $S_{41}$ | 650.60 ± 55.54 | 28.10 ± 2.40 | 0.29 ± 0.03 | 0.013 ± 0.001 | 0.64 |
| $S_{42}$ | 1036.14 ± 189.16 | 44.76 ± 8.17 | 0.47 ± 0.09 | 0.021 ± 0.004 | 1.02 |
| $S_{43}$ | 1951.81 ± 362.49 | 84.31 ± 15.66 | 0.88 ± 0.16 | 0.039 ± 0.007 | 1.91 |
| Average | 961.85 ± 192.56 | 41.55 ± 8.32 | 0.43 ± 0.09 | 0.019 ± 0.004 | 0.94 |
| Maximum | 1951.81 ± 362.49 | 84.31 ± 15.66 | 0.88 ± 0.16 | 0.039 ± 0.007 | 1.91 |
| Minimum | 156.63 ± 78.44 | 6.77 ± 3.39 | 0.07 ± 0.04 | 0.003 ± 0.002 | 0.15 |

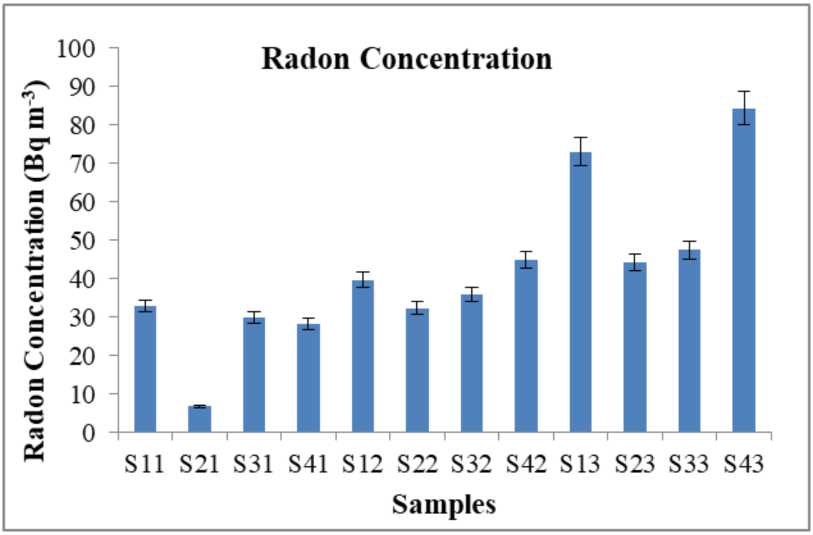


**Figure 6:** The radon concentration in agricultural soil samples from different locations

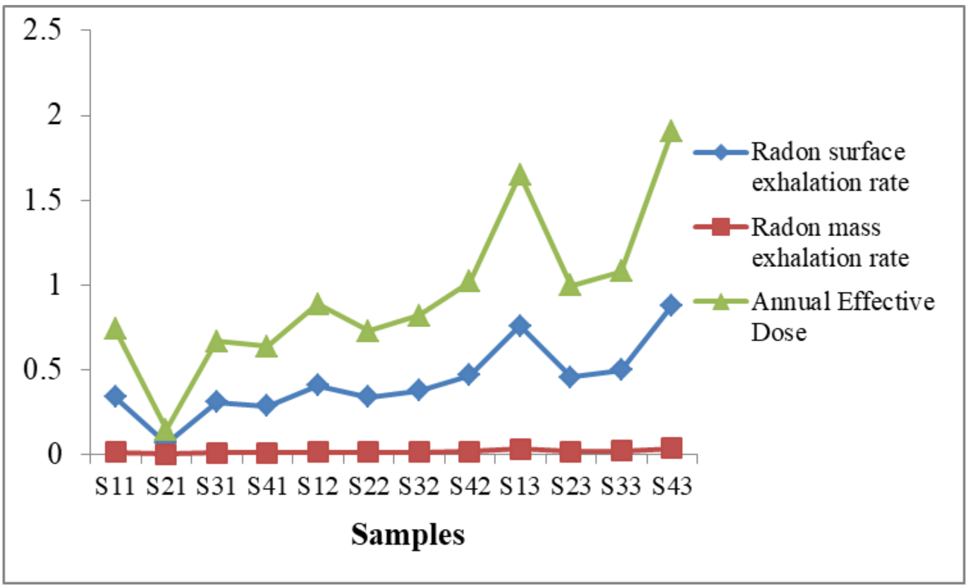


**Figure 7:** The variation of radon surface and mass exhalation rates and annual effective dose in different samples

## Discussion of SSNTD Measurements

All measured values of the radon concentrations are much lower than the recommended ICRP action level of 300 Bq $m^{-3}$. The values of radon concentrations obtained from the study are found to be linearly dependent with exhalation rates. All measured annual effective dose values are below the limit of the recommended action level of 5 m Sv $y^{-1}$. According to these results one can say that, the soil in this area is advisable. Therefore, we can estimate that collected area was not found the pollution of radioactive radiation.

## Determination of Elemental Concentration in Soil Samples

The quantitative results of the soil samples are given in Table 3. The comparison graphs of average elemental concentrations in 12 soil samples are given in Figure 8. The comparison graphs of iron, calcium, potassium and titanium concentrations in 12 soil samples are shown in Figure 9. In qualitative results, the major elements contained in soil samples are observed as silicon, iron, calcium, potassium and titanium. The silicon (Si) was found as major element and the iron (Fe) was second major element in all soil samples. The minor elements were found as zirconium (Zr), manganese (Mn), strontium (Sr), zinc (Zn), chromium (Cr), vanadium (V), yuttium (Y), copper (Cu) and rubidium (Rb) were found in all soil samples.

**Table 3: Quantitative Results of Agricultural Soil Samples for EDXRF Analysis**

| Sample | Elemental Concentration (W%) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Si** | **Fe** | **Ca** | **K** | **Ti** | **Zr** | **Mn** | **Sr** | **Zn** | **Cr** | **Rb** | **V** | **Y** |
| $S_{11}$ | 43.89 | 29.79 | 11.98 | 9.86 | 2.67 | 0.57 | 0.51 | 0.28 | 0.13 | 0.07 | 0.07 | 0.11 | 0.07 |
| $S_{12}$ | 47.95 | 29.95 | 7.79 | 9.88 | 2.67 | 0.51 | 0.53 | 0.26 | 0.13 | 0.09 | 0.09 | 0.08 | 0.05 |
| $S_{13}$ | 48.58 | 28.73 | 8.36 | 9.76 | 2.65 | 0.67 | 0.54 | 0.26 | 0.13 | 0.11 | 0.06 | 0.11 | 0.07 |
| $S_{21}$ | 43.69 | 31.99 | 13.08 | 7.22 | 2.38 | 0.28 | 0.57 | 0.37 | 0.08 | 0.14 | 0.02 | 0.11 | 0.05 |
| $S_{22}$ | 43.75 | 34.07 | 10.46 | 7.46 | 2.53 | 0.35 | 0.61 | 0.44 | 0.10 | 0.07 | 0.01 | 0.07 | 0.05 |
| $S_{23}$ | 46.32 | 29.91 | 11.66 | 7.76 | 2.51 | 0.32 | 0.59 | 0.39 | 0.11 | 0.09 | 0.02 | 0.09 | 0.05 |
| $S_{31}$ | 45.52 | 35.46 | 5.37 | 9.30 | 2.80 | 0.30 | 0.66 | 0.20 | 0.17 | 0.11 | 0.44 | ND | 0.07 |
| $S_{32}$ | 42.24 | 38.32 | 5.39 | 8.87 | 2.74 | 0.29 | 0.69 | 0.21 | 0.18 | 0.11 | 0.03 | ND | 0.08 |
| $S_{33}$ | 46.49 | 33.75 | 6.29 | 9.15 | 2.68 | 0.37 | 0.61 | 0.25 | 0.16 | ND | 0.08 | 0.11 | 0.07 |
| $S_{41}$ | 46.15 | 35.15 | 5.50 | 8.81 | 2.70 | 0.25 | 0.61 | 0.19 | 0.18 | 0.09 | 0.06 | 0.10 | 0.06 |
| $S_{42}$ | 43.49 | 37.34 | 5.68 | 8.83 | 2.81 | 0.31 | 0.67 | 0.21 | 0.20 | ND | 0.09 | 0.13 | 0.07 |
| $S_{43}$ | 46.67 | 34.89 | 5.81 | 8.34 | 2.68 | 0.31 | 0.59 | 0.20 | 0.16 | ND | 0.63 | 0.13 | 0.06 |
| **Average** | **45.40** | **33.28** | **8.11** | **8.77** | **2.65** | **0.38** | **0.60** | **0.27** | **0.14** | **0.07** | **0.09** | **45.40** | **33.28** |

**ND⟶Not Detected**

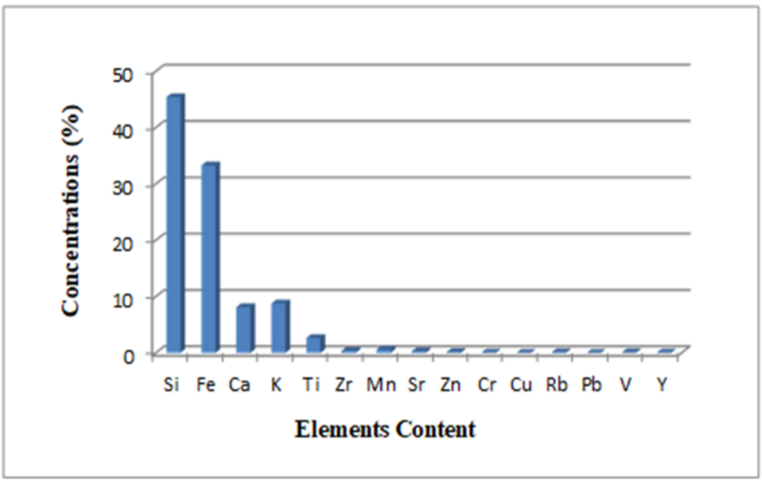


**Figure 8:** Comparison graph of average elemental concentrations in 12 soil samples

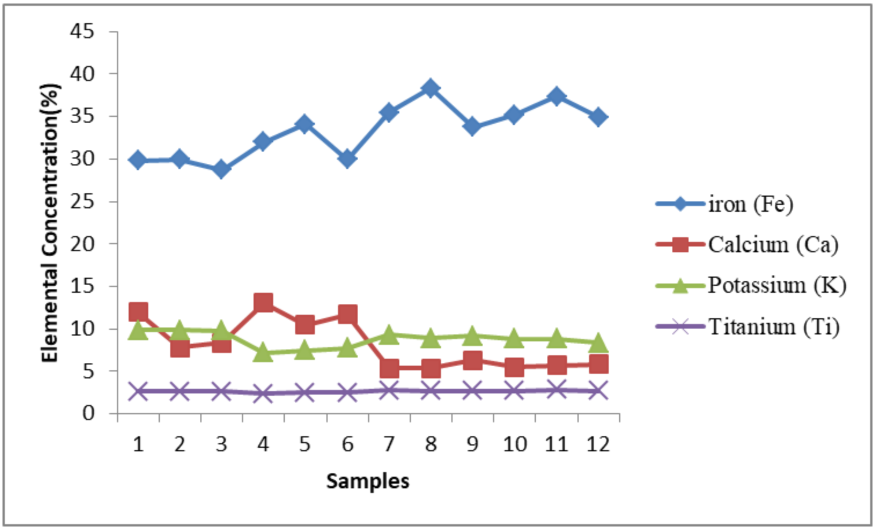


**Figure 9:** Comparison graphs of iron, calcium, potassium and titanium concentrations in 12 soil samples

**Discussion of EDXRF Measurements**

From the quantitative results, the occurrences of the large amount of heavy metal iron concentration were obtained in most soil samples. All of them, the largest amount of the iron concentration (38.32%) were obtained in the soil sample ($s_{32}$) from the 15cm depth of the study area. The collected soil sample between the different places and depths were obtained difference elemental concentration in EDXRF analysis. From the EDXRF analysis, the toxic elements in weight% level were not found.

## Conclusion

The Can technique containing CR-39 plastic track detectors have been used for the measurement of radon concentrations, surface and mass radon exhalation rates, annual effective dose and for the measurement of elemental concentration in soil samples collected from various locations of selected agricultural area.

From the SSNTD's results presented in this study, the lowest values of all measurement results were found in the surface layer of soil sample from west of selected agricultural area in Photokephyu Village while the highest average values of all measurement results were found in the depth 30cm of soil sample from north of selected agricultural area in Photokephyu Village. All measurement results in soil samples are much lower than the recommended ICRP action level. This study shows that the value of radon level increases with the increase in depth. The result shows that this area is safe as for as the health hazards of radon are concerned. From the EDXRF analysis, the radioactive elements and other heavy elements were not determined within weight% level. There were not found toxic elements in weight% level. This studied area is advised to be used as agricultural areas.

Nowadays the environmental health problems tend to apply to an even greater extent to developing countries. Every effort should be made up to keep the concentrations of toxic elements, heavy elements and radioactive elements as low as possible in future for checking of the elemental pollution. The present study will be helpful to understand radiation level in the study area for further studies.

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