

Characterization of ^{137}Cs in Soil from the Surrounding of Al Bayda City, Libya

Salha D. Y. Alsaadi¹, Abdelhmid M. Younis², Areej Hazawi¹,
Najat F. Arhoma³

¹ Physics Department, Faculty of Science, Omar Al-Mukhtar University, Al Bayda, Libya.

² Engineering Materials, Faculty of Engineering, Omar Al-Mukhtar University, Al Bayda, Libya.

³ Physics Department, Faculty of Science, Sirte University, Sirte, Libya.

Corresponding Author: Salha D. Y. Alsaadi

Abstract: This study aimed to measure radioactivity concentrations and to calculate absorbed dose and annual effective dose for ^{137}Cs in 15 soil at depths 0-15 cm from soil surface from five sites around Al Bayda city. Gamma-ray spectroscopy was employed for radiation measurements using HPGe detector. The results showed the ^{137}Cs radioactivity concentration range from 4.0 to 31.0 Bq.kg⁻¹ with average value of 10.87 Bq.kg⁻¹. The absorbed dose rate varied from 0.12 to 0.93 nGy.h⁻¹ with average value of 0.33 nGy.h⁻¹. The outdoor annual effective dose rate varied from 3.97 to 4.56 $\mu\text{Sv.y}^{-1}$ with average value of 1.6 $\mu\text{Sv.y}^{-1}$. The measured values were small in comparison with ICRP(1.0 mSv.y⁻¹) and in other parts of the world.

Keywords: ^{137}Cs , absorbed dose rate, Annual effect dose rate, Al Bayda, Libya.

Date of Submission: 14-09-2018

Date of acceptance: 29-09-2018

I. Introduction

Cesium-137 (^{137}Cs) is anthropogenic radionuclide. It was distributed in the environment as a result of fallout from weapons testing, and nuclear reactors accidents (Rafique, 2014). ^{137}Cs has a half-life about 30.2 years and it has a gamma emission of 661 keV (Dizman et al., 2016). ^{137}Cs was carried out to distant places by winds (Kritidis et al., 2012) and clouds. Then it was deposited on and into the soil surface, water and also in the air. Its radioactivity contributes to the total radioactivity of natural and artificial sources. This leads to increasing concern about the danger to human health and his well being. Many researchers measured the radioactivity concentration for this radioactive element. It was considered as a source of environmental pollution and cause of concern due to exposure to its radiation. Measurement of the radioactivity concentration and absorbed dose rate resulting from the deposition of ^{137}Cs in soil has been cited by many researchers in many countries. Surface soils located in the Al-Kharj, Al-Qassim, Wadi Al-Da- waser, Hail, Al-Jouf, Tabuk, and Riyadh regions of Saudi Arabia were measured using a gamma ray sensor, ^{137}Cs radioactivity in the soils was 10.70 Bq.kg⁻¹. The adsorbed and annual effective dose rates due to ^{137}Cs were 0.34–2.85 nGy.h⁻¹ and 0.0004–0.003 mSv.y⁻¹, respectively. (Al-Hamed, S.A. et al., 2017). Dizman et al reported ^{137}Cs activities in soil samples varied from 75.80±6.30 (Ilyidere district) to 481.81±30.07 (Güneysu district) Bq.kg⁻¹ and average ^{137}Cs activity was found to be 236.38±13.49 Bq.kg⁻¹. (Dizman et al., 2016) The nuclear accident in Fukushima Daichi power plant in 2011 had produced radioactive materials where part of it spread in other parts of the northern hemisphere due to air and clouds movements. Low measurements of ^{137}Cs radioactivity had been recorded in Athens, Greece (Kritidis et al., 2012). Measurements of some radioactive ^{137}Cs was found in some parts of Mediterranean countries such as Croatia (Skoko et al., 2014), and Algeria. (Bramki et al., 2017). ^{137}Cs activity concentration was found to be in the range from 0.36 ± 0.03 to 9.73 ± 0.71 Bq.kg⁻¹ in Aswan, Egypt. (Harb, 2014). In North Kordofan state in Sudan, ^{137}Cs was recorded with a value of 0.28 Bq.kg⁻¹ (Fadol et al., 2015). In Tunis, measurements of ^{137}Cs radioactive concentrations in the soil samples (0–5 cm) gave (1–19 Bq.kg⁻¹). (Mahjoubi, et al., 2006). Another North African nation Algeria, had some concentration of ^{137}Cs radioactivity of an average value of 3.12 Bq.kg⁻¹ (Bramki et al., 2017).

Soil samples were collected from Mirpur of Azad Kashmir. They showed ^{137}Cs activity concentration range from 0.076±0.071 to 2.94±0.17 Bq.Kg⁻¹ with average value of 1.39±0.17 Bq.Kg⁻¹. For soil samples the average values of outdoor, indoor and annual effective dose were found to be 5.12 × 10⁻⁵, 20.47 × 10⁻⁵ and 25.58 × 10⁻⁵ mSv.y⁻¹ respectively. [(Rafique, 2014)]. W.M. Badawy, S.V. Mamikhin made measurements for radioactivity and absorbed dose rate calculation using conversion factor (0.124nGy.h⁻¹ / BqKg⁻¹). (Badawy and Mamikhin, 2012)

So these radioactive materials impose hazard to the human being health. They can transfer to Man through the food chain such as consumption of vegetables, fruits, meat, and milk and through air breathing.

This study aims at the measurement of ^{137}Cs levels in soil samples, in order to set the baseline data for this part of world and to enable detection of an increase in environmental radioactivity.

^{137}Cs presence in soil samples will be an indicator of fallout radioactivity in the area under investigation. Results will be compared with the standards set by international organizations in order to assess the level of threat posed by ^{137}Cs exposure to local population.

II. Material and methods

Soil Samples Collection :

Fifteen soil samples were taken from area surrounding the city of Al-Bayda, Libya. Locations of the collected samples are shown in figure 1. Each sample was collected by selecting a square area of 3 m^2 per site, and the top surface was cleaned from any organic material or debris. Three samples were taken from each square at a depth of 0-15 cm. Each of the three samples of the same site were well mixed together, then all the mixed samples were kept in plastic bags and sent to the laboratory for further treatment to proceed with the analysis.

Preparation of soil samples:

All soil samples were cleaned of stones and organic materials and left to dry in the oven at 70°C for 24 hours. After drying it they were crushed and passed through a 2 mm sieve. Their weights were then measured and kept in plastic bags.

The samples were kept in special container and left for 21 days to reach a state of secular equilibrium. Then they were set for radioactivity measurements using HPGe detector.

Each sample was placed in a Marinelli Beaker to measure the concentration of radioactivity for a measurement time of 3200 seconds.

The activity levels for radionuclides in the measured samples are computed using the following equation (Ibrahim, 1999)

$$A = \frac{A_R}{\epsilon(E)tPW} \quad (1)$$

Where A is the activity level of a certain radionuclide expressed in Bq.kg^{-1} dry weight, A_R is the net counting rate of the sample after subtracting background (counts/s), $\epsilon(E)$ is the counting efficiency of the detector at energy (E), t is the time for the measurement of the samples, P is the absolute transition probability of γ -decay (Abundance (%)), and W is the dried sample weight expressed in kg.

Detection and analysis system:

The high-purity germanium detector (HPGe) which had been used in this study has an efficiency of 70% and an energy resolution of 2 keV at 1332 keV of ^{60}Co gamma transition. During the work, the device needed cooling and the liquid nitrogen was used for this purpose. Figure 2 illustrates a schematic diagram of the system .

III. Results

The concentrations of radioactivity of ^{137}Cs results were published in a previous work[(Alsaadi and Younis, Abdelhamid M., 2015)]. It is found that the activity concentrations values of ^{137}Cs varied from 4 to 31 Bq.kg^{-1} . The average activity concentrations of ^{137}Cs is 10.87 Bq.kg^{-1} . As an example, Fig. 3 shows the gamma-ray spectrum of sample S-10.

Table 1 also shows the absorbed dose rate(D) varied from 0.12 to 0.93 nGy.h^{-1} with an average absorbed dose rate equals 0.33 nGy.h^{-1} , the annual effective dose rate(AEDR) ranged from 0.15 to $1.14\text{ }\mu\text{Sv.y}^{-1}$ with an average $0.40\text{ }\mu\text{Sv.y}^{-1}$.

The AEDR computed in this study was found to be very small as compared with the limit recommended by the International Commission on Radiological Protection (ICRP)for members of the general public is 1 mSv.y^{-1} (Lindell et al., 2005)as well as the average external gamma dose(see Fig. 4) of 0.48 mSv.y^{-1} received per capita from natural radiation sources assessed by UNSCEAR (UNCEAR 2000, 2000)

The conversion factors described by UNSCEAR (2000) were adopted, and the gamma absorbed dose rates were calculated using the following formula:

$$D = 0.03A_{\text{Cs}^{137}} \quad (2)$$

where D dose rate in nGy h^{-1} at 1 m above the ground, and $A_{\text{Cs}^{137}}$ activity concentrations (Bq kg^{-1}) in the soil sample. The gamma absorbed doses in nGy h^{-1} were converted to annual effective dose in $\mu\text{Sv y}^{-1}$, as proposed by UNSCEAR (2000). The annual effective dose rate (AEDR) was calculated using the following equation

$$AEDR(\mu\text{Sv.y}^{-1}) = D * 8760(\text{h.y}^{-1}) * 0.2 * 0.7(\text{SvGy}^{-1}) * 10^{-3} \quad (3)$$

where D is the absorbed dose rate in air (nGy h^{-1}), 0.7 is the dose conversion factor (Sv Gy^{-1}), 0.2 is the outdoor occupancy factor, and 8760 is the time conversion factor (h y^{-1}).

IV. Discussion

The results showed the ^{137}Cs radioactivity concentration range from 4.0 to 31.0 Bq.kg^{-1} with average value of 10.87 Bq.kg^{-1} . The absorbed dose rate varied from 0.12 to 0.93 nGy.h^{-1} with average value of 0.33 nGy.h^{-1} . The outdoor annual effective dose rate varied from 3.97 to 4.56 $\mu\text{Sv.y}^{-1}$ with average value of 1.6 $\mu\text{Sv.y}^{-1}$. The measured values were small in comparison with ICRP(1.0 mSv.y^{-1}) and in other parts of the world.

In some regions of Saudi Arabia, ^{137}Cs radioactivity in the soils was 10.70 Bq.kg^{-1} . The adsorbed and annual effective dose rates due to ^{137}Cs were 0.34–2.85 nGy.h^{-1} and 0.0004–0.003 mSv.y^{-1} , respectively. (Al-Hamed, et al, 2017) . In Rize province of Turkey, reported results for ^{137}Cs activities in soil samples varied from 75.80±6.30 (Ilyidere district) to 481.81±30.07 (Güneysu district) Bq.kg^{-1} and average ^{137}Cs activity was found to be 236.38±13.49 Bq.kg^{-1} . (Dizman et al., 2016) Additional concentration was increased in many places around the world due to nuclear accident in Fukushima Daichi power plant in 2011 which had produced radioactive materials where part of it spread in other parts of the northern hemisphere due to air and clouds movements. Low measurements of ^{137}Cs radioactivity had been recorded in Athens, Greece (Kritidis et al., 2012). ^{137}Cs activity concentration was found to be in the range from 0.36 ± 0.03 to 9.73 ± 0.71 Bq.kg^{-1} in Aswan, Egypt. (Harb et al., 2014). In North Kordofan state in Sudan, ^{137}Cs was recorded with a value of 0.28 Bq.kg^{-1} (Fadol et al., 2015). In Tunis, measurements of ^{137}Cs radioactive concentrations in the soil samples (0–5 cm) gave (1–19 Bq.kg^{-1}). (Mahjoubi et al., 2006). Another North African nation Algeria, had some concentration of ^{137}Cs radioactivity of an average value of 3.12 Bq.kg^{-1} (Bramki et al., 2017).

Soil samples were collected from Mirpur of Azad Kashmir. They showed ^{137}Cs activity concentration range from 0.076±0.071 to 2.94±0.17 Bq.Kg^{-1} with average value of 1.39±0.17 Bq.Kg^{-1} . For soil samples the average values of outdoor, indoor and annual effective dose were found to be 5.12×10^{-5} , 20.47×10^{-5} and 25.58×10^{-5} mSv.y^{-1} respectively. (Rafique, 2014) . W.M. Badawy, S.V. Mamikhin made measurements for radioactivity and absorbed dose rate calculation using conversion factor ($0.124 \text{nGy.h}^{-1} / \text{Bq.Kg}^{-1}$). (Badawy and Mamikhin, 2012)

Agnieszka Dołhańczuk-Śródka in 2012 reported ^{137}Cs concentration varied from 9.2–697.3 Bq.kg^{-1} with an average of 178.9 Bq.kg^{-1} . The absorbed dose rate and the annual effective dose rate were 0.276–20.889 nGy.h^{-1} with average 5.367 nGy.h^{-1} and the annual effective dose rate 0.33–25.6 $\mu\text{Sv.h}^{-1}$. (Dołhańczuk-Śródka, 2012) So these radioactive materials impose hazard to the human being health.

The calculated results from previous works from different locations in the world showed that the absorbed dose rate and the annual effective dose rate still lower than many areas and their limit below 1 mSv . So the concern of transfer to Man through the food chain such as consumption of vegetables, fruits, meat, and milk and through air breathing should be observed by monitoring the concentration of such radioactivity and to have an update for data base

V. Conclusion

Comparing the calculated results of the this work to previous works from different locations in the world showed that the absorbed dose rate and the annual effective dose rate still lower than many areas and their limit below 1 mSv . So the concern of transfer to Man through the food chain such as consumption of vegetables, fruits, meat, and milk and through air breathing should be observed by monitoring the concentration of such radioactivity and to have an update for data base. Continuous concern and monitoring should be done and updating the data base for the concentration is very important especially in cases of nuclear power stations failures anywhere in the world as happened with Fukushima Daichi power plant in 2011 which spread to many areas far away from Japan.

References

- [1]. Al-Hamed, S.A. , Wahby, M. F. , and Aboukarima, A.M., 2017. Evaluation of Natural Radionuclides, Cesium-137 and Radiological Hazard Indices of Agricultural Soils in Saudi Arabia. *J. Nucl. Tech. Appl. Sci* 5, 27–42.
- [2]. Alsaadi, S.D.Y., Younis, Abdelhamid M., M.F.-H., 2015. First International Conference in Basic Science and their Applications, Al-Bayda, Libya, 2015, in: Evaluation of Radioactivity in the Surface Soil in the Surrounding Areas of Al Bayda City, Libya. p. 229.
- [3]. Badawy, W.M., Mamikhin, S.V., 2012. Radioactivity measurement and dose rate calculation due to γ -ray of soil from Chashnikovo – Russia. *Arab J. Nucl. Sci. Appl.* 45, 270–282.
- [4]. Bramki, A., Ramdhane, M., Benrachi, F., 2017. Natural radioelement concentrations in fertilizers and the soil of the Mila region of Algeria. *J. Radiat. Res. Appl. Sci.* 154. doi:10.1016/j.jrras.2017.08.002
- [5]. Dizman, S., Görür, F.K., Keser, R., 2016. Determination of radioactivity levels of soil samples and the excess of lifetime cancer risk in Rize province, Turkey. *Internatuinal J. Radiat. Res.* 14, 237–244. doi:10.18869/acadpub.ijrr.14.3.237
- [6]. Dołhańczuk-Śródka, A., 2012. Estimation of external gamma radiation dose in the area of Bory Stobrawskie forests (PL). *Environ.*

- Monit. Assess. 184, 5773–5779. doi:10.1007/s10661-011-2380-4
- [7]. Fadol, N., Salih, I., Idriss, H., Elfaki, A., Sam, A., 2015. Investigation of Natural Radioactivity levels in Soil Samples from North Kordofan State , Sudan 3, 1–7.
- [8]. Ibrahim, N., 1999. Natural activities of 238 U, 232 Th and 40 Kin building materials. J. Environ. Radioact. 43, 465–469. doi:10.1016/S1350-4487(03)00173-2
- [9]. Kritidis, P., Florou, H., Eleftheriadis, K., Evangelidou, N., Gini, M., Sotiropoulou, M., Diapouli, E., Vratolis, S., 2012. Radioactive pollution in Athens, Greece due to the Fukushima nuclear accident. J. Environ. Radioact. 114, 100–4. doi:10.1016/j.jenvrad.2011.12.006
- [10]. Lindell, B., Dunster, H.J., Valentin, J., 2005. International commission on radiological protection 1, 1–110.
- [11]. Mahjoubi, H., S. Labidi, S. Mtimet, F. Essafi, F.B.C., 2006. Survey of natural and artificial radioactivity in Tunisian soils H. Mahjoubi*, S. Labidi and S. Mtimet. Int. J. Low Radiat. 2, 60–70. doi:10.1504/IJLR.2006.007896
- [12]. Rafique, M., 2014. Cesium-137 activity concentrations in soil and brick samples of Mirpur, Azad Kashmir; Pakistan. Int. J. Radiat. Res. 12, 39–46.
- [13]. S. Harb, A. H. El-Kamel, A. I. Abd El-Mageed, A. Abbady, W.R., 2014. Radioactivity Levels and Soil-to-Plant Transfer Factor of Natural Radionuclides from Protectorate Area in Aswan , Egypt. World J. Nucl. Sci. Technol. 4, 7–15.
- [14]. Salvatore Rizzo, E.T. and G.V., 1981. ENVIRONMENTAL RADIOACTIVITY MEASUREMENTS IN THE MEDITERRANEAN AREA, in: 7 Th International Symposium on Environmental Pollution and Its Impact on Life in the Mediterranean Region. pp. 2437–2447.
- [15]. Skoko, B., Marovi, G., Babi, D., 2014. Radioactivity in the Mediterranean flora of the Ka stela Bay, Croatia. doi:10.1016/j.jenvrad.2014.04.005
- [16]. UNCEAR 2000, 2000. Sources and Effects of Ionizing Radiation.

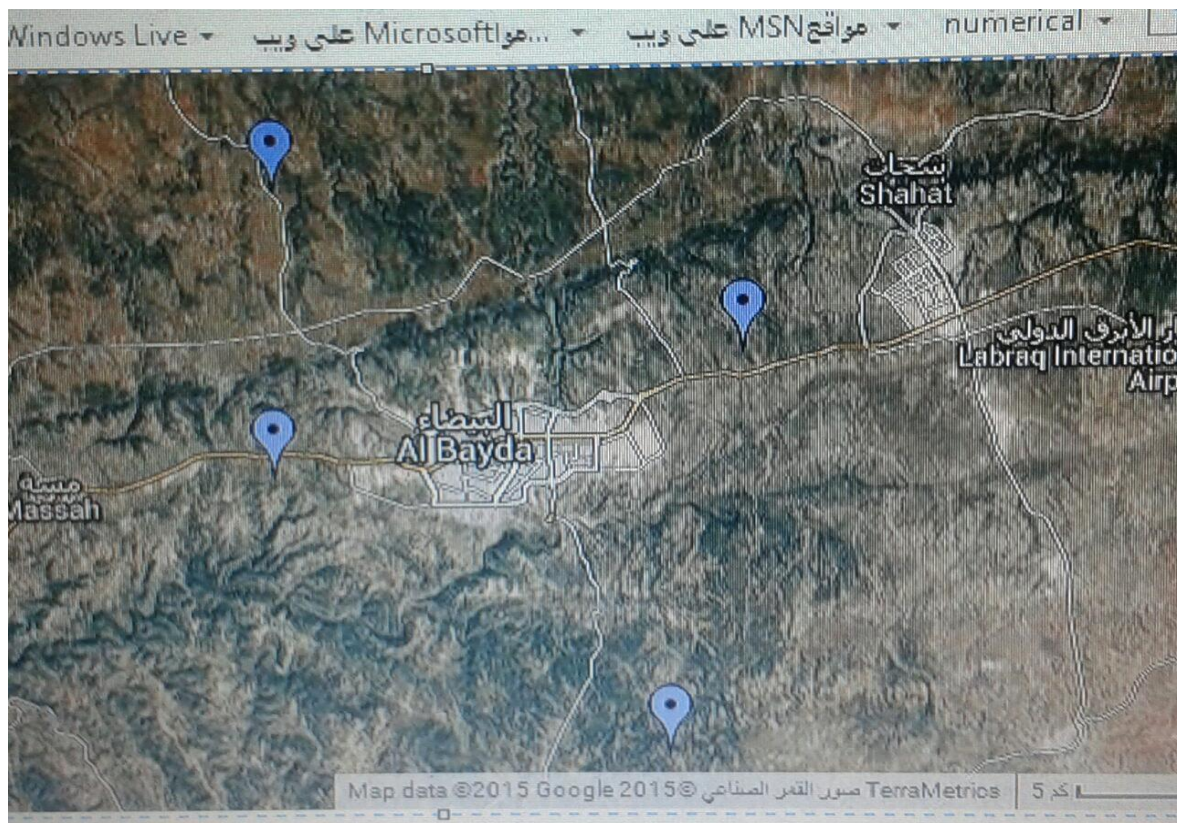


Fig. 1: The sites of samples in Al Bayda city.

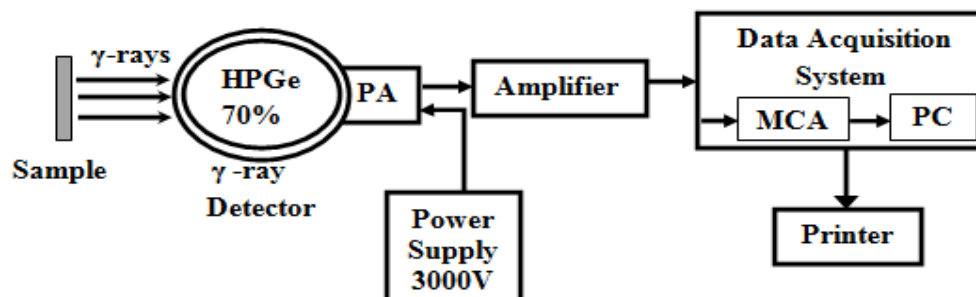


Fig. 2: Schematic diagram form of (HPGe) gamma system

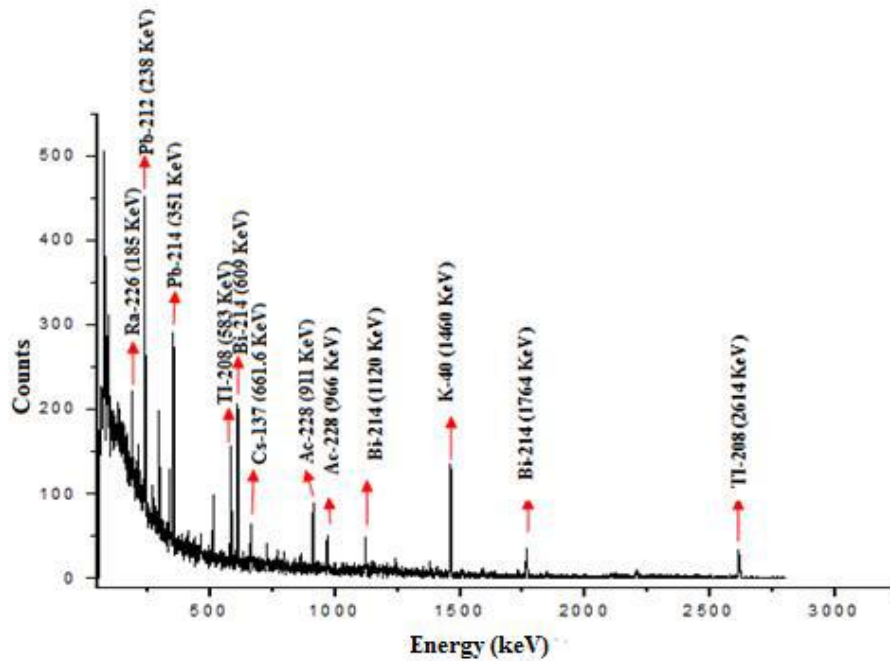


Fig. 3: The gamma-ray spectrum of the soil sample S-10.

Table 1: ^{137}Cs concentration, absorbed dose rate, Annual effective dose rate

Sample ID	Cs-137(Bq.kg ⁻¹)	Absorbed Dose Rate (nGy.h ⁻¹)	Annual Effective Dose Rate(μSv.y ⁻¹)
S-1	7	0.21	0.26
S-2	4	0.12	0.15
S-3	8	0.24	0.29
S-4	5	0.15	0.18
S-5	7	0.21	0.26
S-6	9	0.27	0.33
S-7	14	0.42	0.52
S-8	7	0.21	0.26
S-9	7	0.21	0.26
S-10	9	0.27	0.33
S-11	7	0.21	0.26
S-12	31	0.93	1.14
S-13	11	0.33	0.40
S-14	19	0.57	0.70
S-15	18	0.54	0.66
Average	11	0.33	0.40
Max	31	0.93	1.14
Min	4	0.12	0.15

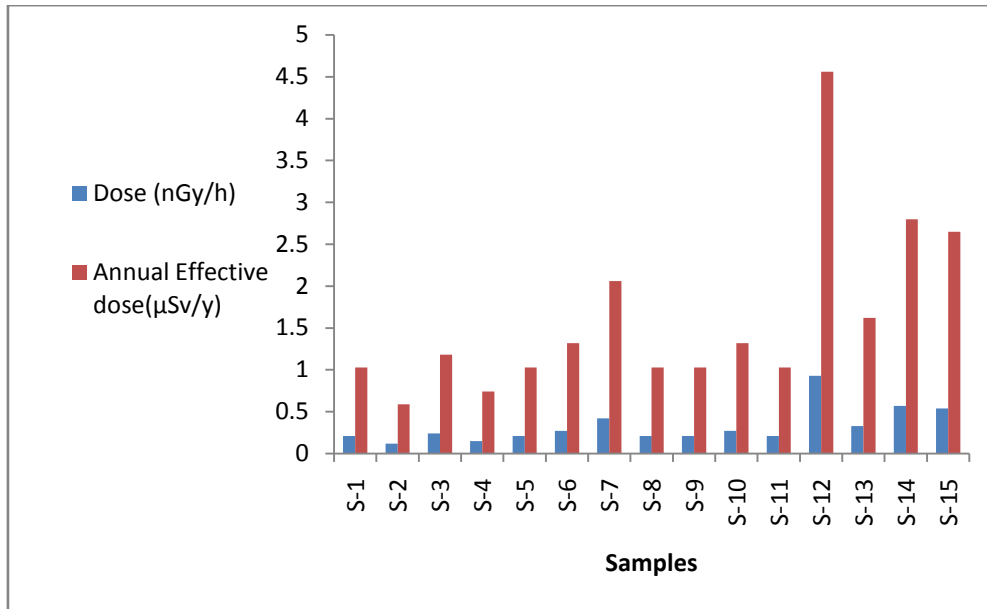


Fig. 4 Dose rate and annual Effective dose rate

IOSR Journal of Applied Physics (IOSR-JAP) is UGC approved Journal with Sl. No. 5010, Journal no. 49054.

Salha D. Y. Alsaadi "Characterization of ^{137}Cs in Soil from the Surrounding of Al Bayda City, Libya" IOSR Journal of Applied Physics (IOSR-JAP) , vol. 10, no. 5, 2018, pp. 26-31.