Arab J. Nucl. Sci. Appl., Vol. 56, 5, 63-68 (2023)

ISSN 1110-0451

Arab Journal of Nuclear Sciences and Applications

Web site: ajnsa.journals.ekb.eg

(E S N S A)

Cs-137 Activity in Fly Ash from Al-Hartha Thermal Power Station in The South of AL Basra City

I. K. Ahmed[1] and Mostafa. Y.A. Mostafa[2*]

[(1)] *physics Department, college of science, University of ANBAR, IRAQ*

[(2)] *Department of physics, faculty of science, Minia University, 61519 El-Minia, Egypt*

ARTICLE INFO

Article history:

Received: 6th Apr. 2023

Accepted: 6th June 2023

Available online: 12th Aug. 2023

Keywords:

Cesium (Cs-137);
fly ash;
TENORM;
gamma spectroscopy;
effective dose.

ABSTRACT

Cesium (Cs-137) is a technically enhanced natural radioactive element TENORM. Cs-137 is presented out of nuclear accidents as an example of anthropogenic radionuclides. In this paper, the activity concentration of Cs-137 is estimated in fly ash samples with a NaI (Tl) detector (gamma spectroscopy). It has high efficiency for gamma measurements. Fly ash samples were collected from the electric thermal power station Al-Hartha at Basra city in the south of Iraq. About fourteen samples were collected, prepared, and measured. The Cs-137 activity concentration is found between 0 (BDL, blew detection limit) to 28±7 Bq kg^{-1} for the fly ash samples from electric thermal power station Al-Hartha. All measured values are lower than the worldwide background level (UNSCEAR recommendation 37 Bq kg^{-1}). Also, the obtained Cs-137 activity concentration has no effect on the estimated effective dose rate, that be prophesied with the activity of Cs-137 and cosmic radiation. The Cs-137 contribution in the estimation of absorbed dose rate will discuss and calculation will present for the measured activity.

INTRODUCTION

Cs-137 is considered one of the artificial radioactive materials. It is a mutual production of reactions in nuclear fission that happen in reactors, or in nuclear weapons, exercised for the generation of electricity at nuclear power plants (NPP). It has a high relative hazardous due to its long half-life (30.1 year). Cs-137 can enter the biological system of humans with the chain of food through the soil or water [1, 2]. The radiation hazards to the health of humans have become a considerable civic concern worldwide. However, radiation is an inevitable portion of the environment by the connection with water, soil, rocks, and sediments etc [3]. Humans' radiation exposure primary sources are fundamentally natural, another small bit is from nuclear tests as anthropogenic, techno genic, etc. The majority comes from natural radiation sources in different environments [4].

In the ambient environment, the main Cs-137 source is the accidents of NNPs such as Chornobyl and Fukushima. In such accidents, considerable amounts of radionuclides were emitted or released into the air and still have effects on the cycle of life [5, 6]. The radionuclides Cs-137 first existed in the atmosphere's upper layer and then conveyed tardy to the atmosphere's lower layers. Ultimately, it is deposited progressively towards the earth. This cycle is the reason for an increase in the radioactivity level in extreme areas. When Cs-137 as radioactive material is released into the air, it has a chance to fly thousands of kilometers before settling on the ground. Cs contaminated food Ingestion is the internal exposure major source of radiation exposure. Also, exposure due to inhalation and dermal contact is also potential. The concentration Cs-137 levels in sediments and soil were estimated and reported by different studies [7, 8].

In present days, thermal power stations are used by countries worldwide with sundry fuel types such as coal, oil, natural gas, lignite, and diesel. Fly ash is generated in these stations by considerable amounts. Fly ash production at stations of electric power or water desalination presents the most elimination of waste and problems of management. The accumulated ashes are recognized as serious ecological trouble [9]. In numerous countries, the fly ash fraction is collected with mechanical and electrostatic precipitators. Then, it is treated as profitable and trade materials used in building. Therefore, the fly ash radioactive properties have effects on the radioactivity level in indoor air, particularly in the places with low ventilation [10].

Preceding studies stated that the generated fly and bottom ash in thermal plants power implicate spare on the levels of NORM [11]. Furthermore, the interest universal in NORM measuring in oil ash and coal ash has increased

Corresponding author: mostafa.youness@mu.edu.eg
DOI: 10.21608/ajnsa.2023.204483.1741

with considering the health hazards of radiation [12]. Many of the previous studies focused on the created ash by power stations worked by coal and few studies were conducted on ash created in power stations based on heavy oil and natural gas [13].

Most of studies about monitoring of Cs-137 in the fly ash were in Japan. These studies founded a high cesium concentration level due to Cs-134 and Cs-137 (4000-5000 Bq kg^{-1}), due to the Fukushima accident in NPP [14]. However, these founded of radioactive cesium levels in fly ash are less than the regulatory limit of power plants (8000 Bq kg^{-1}) [15, 16]. In Iraq, Cs-137 activity concentrations are measured in samples of fly ash from two electrical stations of thermal electrical power (Al-Musaeb and Al-Naserya) and was 36 ±23.8 Bq kg^{-1} and 59±43.1 Bq kg^{-1} for Al-Musaeb station and Al-Naserya station respectively [8].

Therefore, the aim of the present work is the estimation of Cs-137 activity (Bq kg^{-1}) in contaminated fly ash samples from electric thermal power station Al-Hartha at Basra city in the south of Iraq. A NaI (Tl) detector gamma ray spectroscopy with acceptable efficiency is utilized to obtain activity. The Cs-137 absorbed dose (D_a) and annual effective dose (AED) of Cs-137 results are compared to the worldwide recommendations from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

EXPERIMENTAL WORK

Fourteen contaminated fly ash samples were collected from several points at the thermal electric power station (Al-Hartha) in the south of Basra (30º 67'75''N-47°75'44''E). As shown in figure 1, the station photo and example for the points of sample collections. Al-Hartha electric thermal power station is working with fuel of oil or coal. Example of collected sample is shown in figure 2. Table 1 presents locations of collected Samples.

The ISO protocol is applied for the fly ash samples preparation [17]. The samples of fly ash were crushed, grinded and then dried to remove the residual moisture at room temperature. Dring process continuo until samples are achieved a constant weight. Following that, fine powder samples are obtained by pulverization. Nearly one kilogram of sample is placed into a Marinelli beakers. A NaI (Tl) γ-spectrometer with ahigh efficiency is utilized to estimate a Cs-137 activity concentration, in Bq kg^{-1} [13]. Each sample was measured on detector for sufficient time (several hours), to get a high-count rate with sufficient statistic. The uncertainty was lower than 5% in the applied γ-measurement. To avoid external radiation from the background, lead-shielding is utilized. The background spectrum is subtracted from the spectrum of sample. The uncertainty of activity concentration (Δ) is estimated considered the counts associated errors and radionuclide peaks analysis, the branching γ-emission, calibration of energy, efficiency, and mass of sample [18].

The Cs-137 radiological hazard is estimated with worldwide indexes, the air absorbed dose rate (D_a) and the annual effective dose (AED).

The air absorbed dose rates D_a (nGy h^{-1}) is estimated by multiplying the value of Cs-137 activity concentration by the dose conversion factor of cesium of 0.03 (nGy kg h^{-1} Bq^{-1}).

$$D_a = C\,(\text{Cs-137}) \times 0.03 \qquad \textbf{(1)}$$

While the AED (mSv y^{-1}) is obtained applying the next equation

$$AED = D_a \times 0.7 \times 8760 \times 10^{-6} \qquad \textbf{(2)}$$

The value of Cs-137 activity concentration Bq/kg, that were calculated by using NaI (Tl) by using counting system after stopping it at Energy 661.7 Kev, as show in this figure 3.

Fig. (1): the station photo and example for the points of sample collections.

Fig. (2): Example of collected sample.

Table (1): Samples collection locations.

Sample Number	location
S1	Pulverize
S2	Coal tower
S3	From the bottom of the inside oven
S4	Condenser
S5	Pump / feed water
S6	Floor furnace
S7	The bottom of the oven from abroad
S8	Turbine / outside
S9	Ash hopper
S11	From chimney1
S12	From chimney2
S13	From chimney3
S14	Coal hopper

RESULTS AND DISCUSSION

The activity concentrations of Cs-137 are measured in the contaminated fly ash samples from the electric thermal power station Al-Hartha, at Basra city in the south of Iraq. They were founded ith a range from 0 (BDL, blow detection limit) to 28±7 Bq kg^{-1} with a value of average 11.64±7.9 Bq kg^{-1}. Figure 4 shows the frequency of Cs-137 activity concentration in fourteen samples of contaminated fly ash from the electric thermal power station Al-Hartha. The mean values, minimum and maximum of ^{137}Cs specific activity concentrations are presented in Figure 5.

Compared to the recommended values from reports of UNSCEAR, the Cs-137 average is limited to 37 Bq kg^{-1}, all obtained results are lower than this limit [19]. These cesium levels away from other studies with milled soils in Iraq, it was founded with range 0.5 - 175.0 Bq kg^{-1}. It’s due to the tests of nuclear weapons and accidents like Chernobyl [20]. Also, the lower ^{137}Cs activity concentrations are lower than the other fly ash measurements from other stations of thermal electric power in Iraq (south also, Al-Musaeb and Al-Naserya). The activity concentration of Cs-137 were 36 ±23.8 Bq kg^{-1} and 59±43.1 Bq kg^{-1} for Al-Musaeb and Al-Naserya stations respectively [8].

These values are a guide that the dose will receive from exposure to these Cs-137 concentrations be less than the limit of background and worldwide. It means that the measured activity concentration of Cs-137 in contaminated fly ash from the electric thermal power station Al-Hartha does not add value to the dose rate. In the estimation of absorbed dose rate, with Cs-137 activity contribution, a conversion coefficient of 0.136 (nGy h^{-1} per Bq kg^{-1}) is applied. In the normal case, the air inhaled by humans for 70 years must give a radiation dose lower than (1 mSv y-1) as a dose limit. For Cs-137, to achieve an acceptable limit of dose Cs-137 activity /30 ≤1.

Figure 3 shows the box chart of the air absorbed dose rate (D) from Cs-137 and the Cs-137 annual effective dose (AED) for the collected contaminated fly ash samples from the electric thermal power station Al-Hartha, at Basra city in the south of Iraq. The absorbed dose rate mean is 0.35±0.19 nGy h^{-1} at the electric thermal power station Al-Hartha, while the mean AED is 0.0022±0.0009 mSv y^{-1}. These values are within the ranges recommended by UNSCEAR 0.10-15.0 nGy h^{-1} and 0.0010-0.070 mSv y^{-1}. These recommendations are taken on the base of different measurements around the world [20].

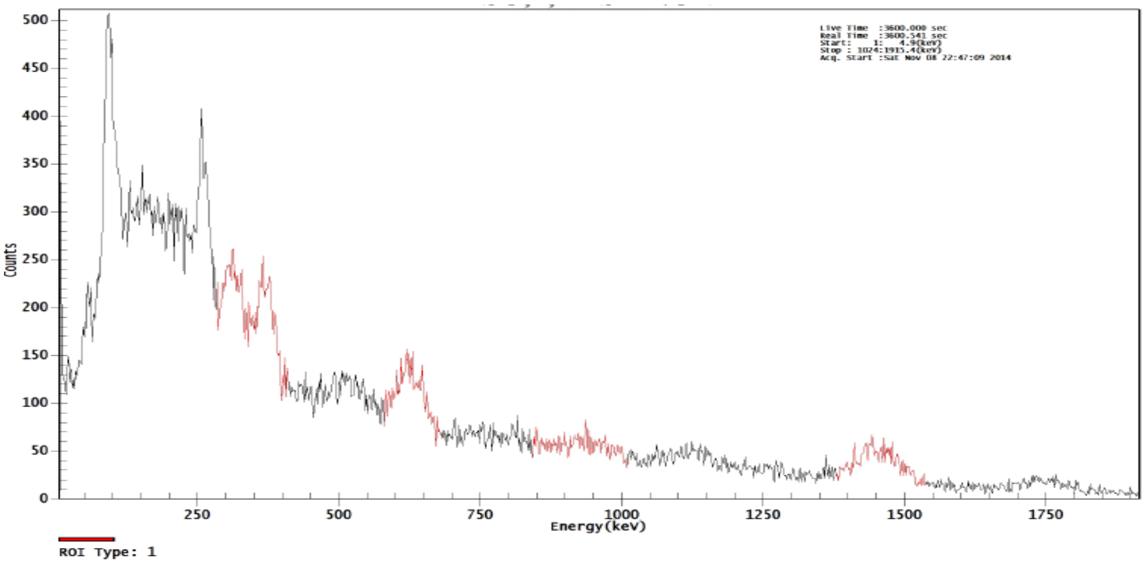

Fig. (3): Example of count rate for one sample.

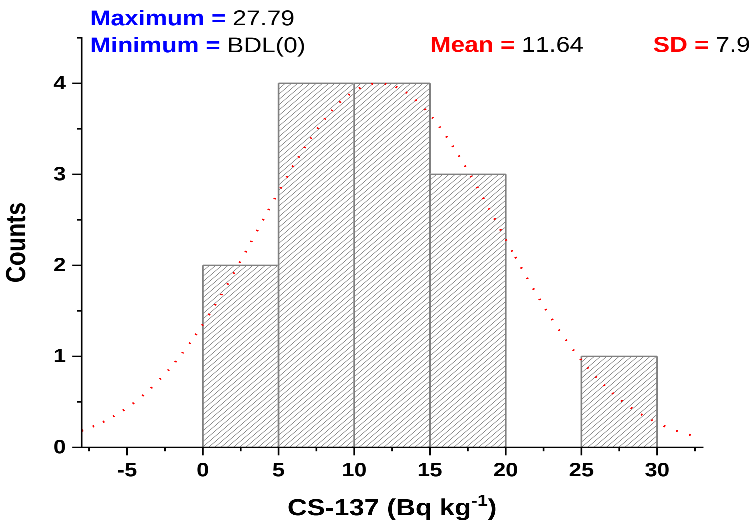

Fig. (4): ^{137}Cs activity concentration frequency for the collected samples of contaminated fly ash from the electric thermal power station Al-Hartha, at Basra city in the south of Iraq.

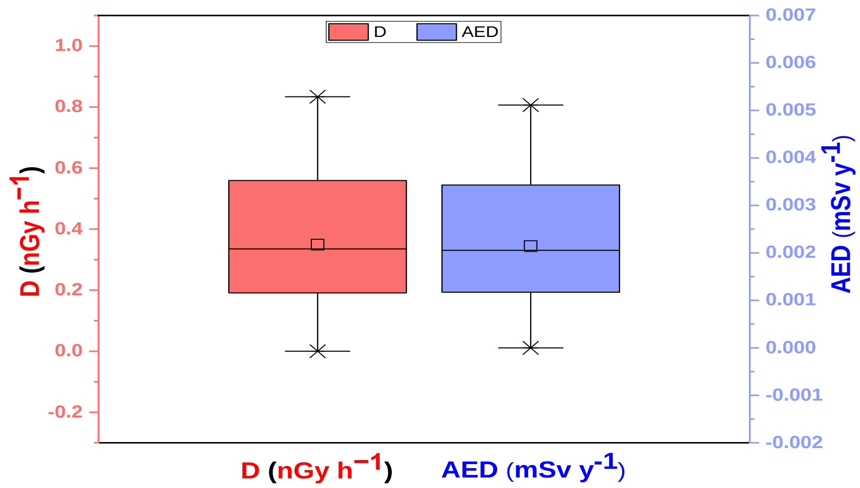

Fig. (5): The ^{137}Cs absorbed dose rate (Da) and the137Cs annual effective dose (AED) for the collected fly ash samples from the electric thermal power station Al-Hartha, at Basra city in the south of Iraq.

CONCLUSION

The activity concentration of Cs-137 (Bq kg^{-1}) in the contaminated fly ash samples that collected from electric thermal power station Al-Hartha, at El-Basra city in the south of Iraq, was measured utilizing a high-efficiency NaI (Tl) detector. This activity is used to estimate the hazard due to Cs-137. The specific 137Cs mean activity concentration is 11.64±7.9 Bq kg^{-1} for the collected fly ash samples. All measured values are lower than the worldwide and background limit (UNSCEAR, 37 Bq kg^{-1}). No additional value to the effective dose rate is found. The obtained results in the present study give a piece of information as a future baseline for the expected work of measuring and estimating the thermal power stations' fly ash impaction in Iraq.

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