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Araştırma Makalesi / Research Article

Environmental Gamma Dose Measurement in Arin Lake (Bitlis)

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Abstract

Arin Lake is a stopover for many migratory bird species, mostly flamingos and songbirds.The assignment of gamma dose rate is very important for the air quality of an environment and human health. For this purpose, the environmental gamma radiation dose rate in air was measured for 27 different point in Arin Lake area in Bitlis province. Measurements were conducted using a portable gamma survey meter supplied with a NaI(Tl) scintillation detector. Gamma dose values were measured in the range 0.035 - 0.165 μSv/h for ground level with mean 0.117 μSv/h. Similarly gamma dose values for 1 m above the ground were measured in the range 0.027 - 0.150 μSv/h with mean 0.104 μSv/h.

Keywords: Environmental Gamma, Effective Dose, Arin Lake

Bitlis Arin Gölünde Çevresel Gama Doz Ölçümü

Öz

Arin gölü, çoğunlukla flamingolar ve ötücü kuşlar olmak üzere çok sayıda göçmen kuş türü için göçmen kuşların göç yolunda mola yeridir. Gama doz oranın belirlenmesi, bir ortamın hava kalitesi ve insan sağlığı için çok önemlidir. Bu amaçla, Bitlis ilindeki Arin Gölü bölgesinde 27 farklı nokta için havadaki çevresel gama radyasyon dozu ölçülmüştür. Ölçümler için NaI(TI) sintilasyon dedektörüne sahip taşınabilir gama ölçüm cihazı kullanılmıştır. Gama doz oranı değerleri yer seviyesi için 0,035-0,165 μSv/h aralığında ve ortalama 0,117 μSv/h olarak ölçülmüştür. Benzer şekilde, yerden 1 m yükseklik için gama doz oranı değerleri 0,027-0,150 μSv/h aralığında ve ortalama 0,104 μSv/h olarak ölçülmüştür.

Anahtar Kelimeler: Çevresel Gama, Efektif Doz, Arin Gölü.

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1. Introduction

People are continuously exposed to cosmic radiation and terrestrial radiation throughout their lifetimes. The geographic characteristics of a location, such as altitude, latitude-longitude coordinates, and the amount of incident solar radiation usually determine the effect of cosmic radiation (UNSCEAR 2010; Karatepe 2019; Pashazadeh 2014). Terrestrial radiation originates from the geological features of the area, encompassing rock formations, soil compositions, water sources, and air (Bal 2015). Terrestrial radiation generally emanates from naturally occurring isotopes such as ^{238}U, and ^{232}Th, ^{40}K, as well as artificially generated isotopes such as ^{137}Cs, ^{90}Sr, ^{239}Pu, and their respective radioactive decay products (SureshGandhi 2014; Bal 2018).

Numerous studies have been conducted worldwide to investigate exposure to gamma radiation. These investigations have shed light on the effects of radiation on human health and have demonstrated the adverse consequences associated with such effects (Avwiri 2016; Ramola 2011, Amiranashvili 2021; Hazrati 2012).

Lakes are formed through various factors such as tectonic movements, volcanic activities, glacier formation, erosion, and the influence of rivers (Duman 2012). It is essential to determine the environmental radiation due to the water, soil, and rock structure of the lake and its surroundings. Therefore, in this study, environmental gamma dose measurements were conducted in and around Lake Arin, located within the borders of Bitlis province. Based on the obtained results, the annual effective dose rate (AED) and lifetime cancer risk values (ELCR) were determined. Thus, the impact on human health was determined. Additionally, an evaluation was conducted to determine whether the results exceeded the values suggested by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and a comparison was made with results from other studies (UNSCEAR 2010).

2. Materials and Methods

2.1. Study Area

Arin Lake, located in Adilcevaz district of Bitlis province, is a soda lake that spans approximately 13.5 km^2 in area. The lake constitutes a stopover site for a multitude of migratory bird species, predominantly including flamingos and songbirds, along their migratory route (Nergis 2017). In addition, during the Ottoman Empire period, the lake was utilized for soda production (Yücel 2020). Map of Arin Lake and locations of samples is shown in Figure 1.

Figure 1. Map of Arin Lake and location of study area.

2.2. Dose Rate Measurement

Gama dose values were measured at 27 different locations around Lake Arin. The measurements were taken at ground level and at a height of 1 m above ground, and the average of three measurements performed for each point was calculated. Measurements made using LUDLUM Model 2241 Digital Scaler/Ratemeter and LUDLUM Model 44-10 Prob. Prob is a scintillation detector that consists of 2"x2" NaI (Tl) crystal (Ludlum 2012). The annual effective dose values (AED) are calculated by following equation;

$$\text{AED } (\mu Sv/y) = \text{Dose rate}(\mu Sv/h) \times 0.2 \times 8760 h/y \quad (1)$$

Here 0.2 is the occupancy factor for outdoor (UNSCEAR 2000). Excess lifetime cancer risk (ELCR) is determined using by the equation;

$$ELCR = AED \times DL \times RF \quad (2)$$

Where DL is average lifespan of people (70 years) and RF is a risk factor that is a fatal cancer risk per sievert. International Commission on Radiological Protection (ICRP) recommended RF be 0.057 for the people (ICRP 2007)

3. Findings and Discussion

Environmental gamma dose values were determined at 27 points around Arin Lake. Measurements were made on the ground and at a height of 1m from the ground. The gamma dose

measurements and frequency distribution of gamma dose are observed in Table 1 and Figure 2 and Figure 3.

Table 1. Environmental gamma dose value and the annual effective dose rate at Arin Lake area.

Sample Number	Latitude	Longitude	Ground (μSv/h)	Above 1m (μSv/h)	AED (mSv/y)	ELCR(x10^{-3})
1	37.82500	42.993766	0.165	0.142	0.249	0.994
2	38.825284	42.992193	0.145	0.135	0.237	0.946
3	38.825237	42.990698	0.162	0.145	0.254	1.013
4	38.825122	42.989172	0.161	0.148	0.259	1.033
5	38.825079	42.987646	0.132	0.124	0.217	0.866
6	38.825362	42.986032	0.152	0.136	0.238	0.950
7	38.825703	42.984469	0.122	0.104	0.182	0.726
8	38.826147	42.982948	0.075	0.063	0.110	0.439
9	38.826565	42.981319	0.068	0.061	0.107	0.427
10	38.82782	42.979637	0.076	0.070	0.123	0.491
11	38.826428	42.977649	0.076	0.067	0.117	0.467
12	38.825552	42.9752263	0.083	0.075	0.131	0.523
13	38.82428	42.973228	0.105	0.092	0.161	0.642
14	38.822981	42.97129	0.105	0.096	0.168	0.670
15	38.82172	42.969428	0.116	0.106	0.186	0.742
16	38.821221	42.967712	0.128	0.112	0.196	0.782
17	38.82038	42.961985	0.108	0.093	0.163	0.650
18	38.818336	42.958989	0.165	0.150	0.263	1.049
19	38.815001	42.957553	0.156	0.146	0.256	1.021
20	38.811867	42.957905	0.145	0.140	0.245	0.978
21	38.804191	42.967359	0.112	0.103	0.180	0.718
22	38.801947	42.972152	0.112	0.097	0.170	0.678
23	38.798617	42.97882	0.114	0.107	0.187	0.746
24	38.79504	42.993771	0.108	0.091	0.159	0.634
25	38.796174	43.002281	0.141	0.110	0.193	0.770
26	38.801645	43.006884	0.092	0.074	0.130	0.519
27	38.820100	43.001563	0.035	0.027	0.047	0.188
Min			0.035	0.027	0.047	0.188
Max			0.165	0.150	0.263	1.049
Mean			0.117	0.104	0.183	0.728
UNSCEAR			0.041		0.074	0.29

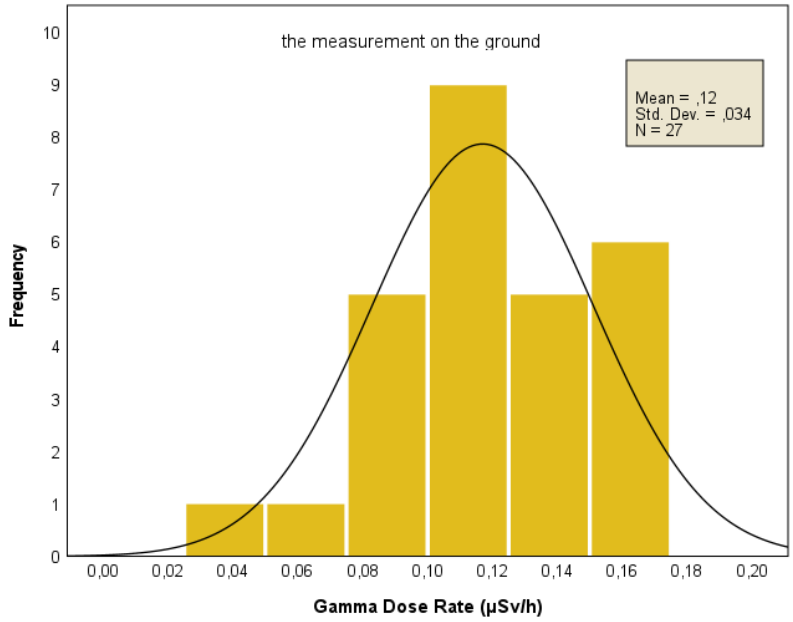

Figure 2. Frequency distributions of gamma dose rate on the ground.

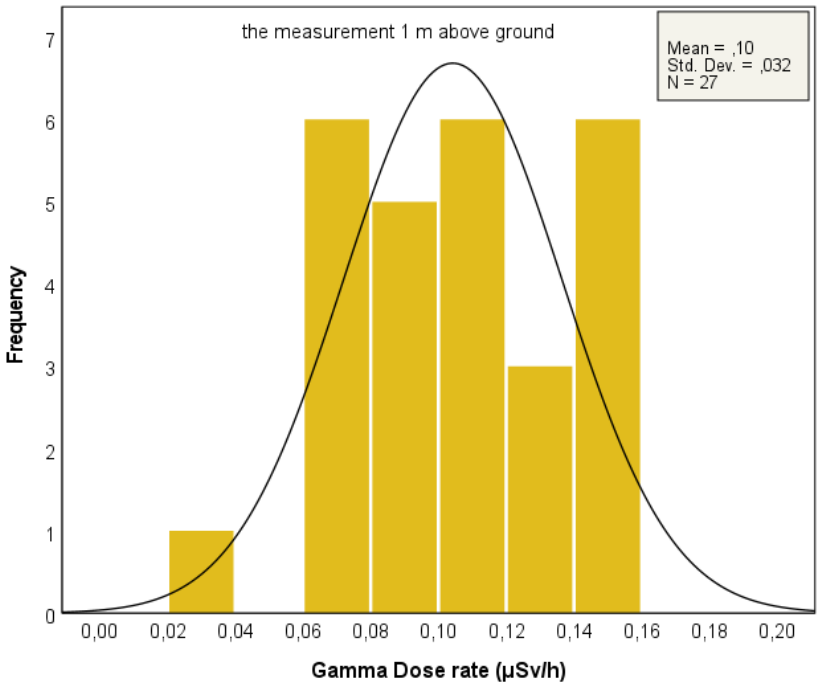

Figure 3. Frequency distributions of gamma dose rate on 1m above ground.

As seen in Table 1, the gamma dose measurement on the ground, which contains almost all of the gamma radiation emitted from the soil at all measurement points, is greater than the value measured at 1m above the ground. The maximum gamma dose value is 0.165 µSv/h and the minimum gamma dose value is 0.035 µSv/h at the ground level. The mean gama dose value was determined as

0.117 µSv/h at the ground level. Likewise, the maximum value was found to be 0.150 µSv/h, while the minimum value measured at a height of 1 meter from the ground was 0.027 µSv/h. The mean dose value was calculated as 0.104 µSv/h. These mean values are exceed the world average value of 0.041 µSv/h (59 nGy/h) recommended by UNSCEAR (UNSCEAR 2000). But, the value at location 27 is below the world average.

As given in Table 1, it is observed that the annual effective dose (AED) calculated from the gamma dose value measured at a height of one meter from the ground has a minimum of 0.047 mSv/y, a maximum of 0.263 mSv/y, and the mean value of 0.183 mSv/y. In the UNSCEAR (2000) report, the world average value of AED is 0.74 mSv/h (73.6 µSv/h) (UNSCEAR, 2000). In this study, the average value determined for AED is 0.183 mSv/h, which is above the world average value. The frequency distribution of AED values is shown in Figure 4.

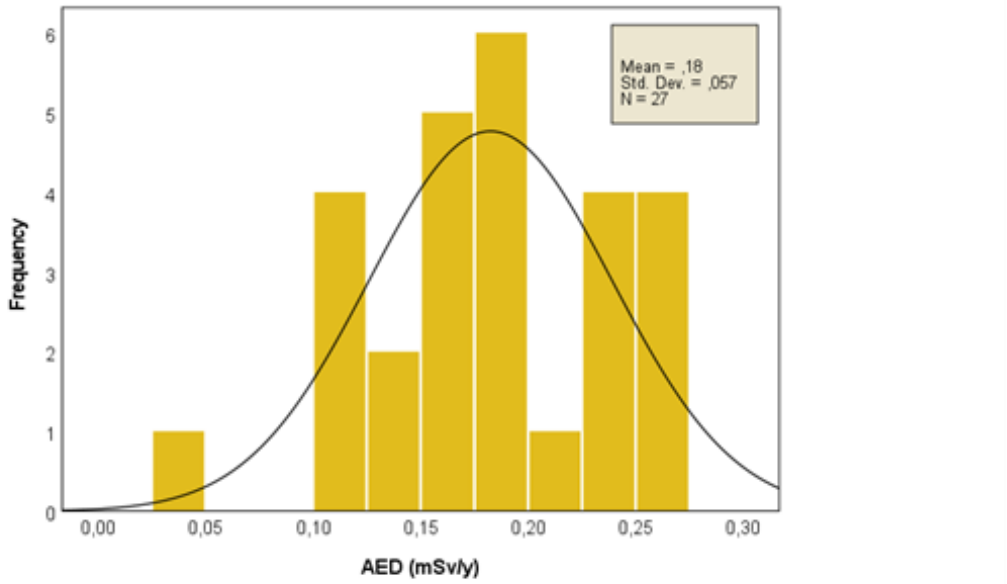

Figure 4. Frequency distributions of the annual effective dose (AED)

The highest value calculated for the lifetime cancer risk (ELCR) assessment at a height of 1 m above the ground was 1.049×10^{-3}, and the lowest value was 0.188×10^{-3}. The mean value was calculated as 0.728×10^{-3}. The results obtained for ELCR are presented in Table 1. It was determined that the average values obtained in this study were higher than the world average value (0.29×10^{-3}) (UNSCEAR, 2000).

The results of similar studies in some countries are given in Table 2.

Table 2. Comparison of the results of the gamma radiation from this study with studies in some countries.

Area	Dose Rate (μSv/h)	AED (mSv/y)	ELCR (x 10^{-3})	References
Kulakçayırı Lake Türkiye	0.022 - 0.033	0.039-0.058	-	Kam 2016
Uburu Salt Lake, Nigeria	0.150	0.063	1.173	Avwiri 2017
Kerala, India	-	1.042	-	Thomas 2022
Kashmir, Pakistan	-	0.497	-	Rafique 2013
Dhaka, Bangladesh	0.187	0.328	1.3	Hossain 2019
Tsugaru, Japan	0.020	0.24	-	Iyogi 2002
Ardebil, Iran	0.110-0.680	1.73	-	Hazrati 2012
This study	0.117	0.183	0.728	
UNSCEAR	0.041	0.074	0.29	UNSCEAR 2000

As seen in Table 2, the AED value in this study is lower than for other results, except for the values of Kulakcayiri Lake Turkiye and Ubutu Lake Nigeria (Kam 2016; Avwiri 2017). The lowest value, which is even lower than the value recommended by UNSCEAR, is observed in Kulakçayırı Lake, Türkiye. In addition, the highest AED value was obtained in Ardebil Iran (Avwiri 2017).

4. Conclusions and Recommendations

The determination and assessment of environmental gamma radiation is important for human health. In pursuit of this objective, environmental gamma dose measurements were conducted in the area of Lake Arin. In this study, according to the results, the mean gamma dose value exceeds the recommended value by UNSCEAR. Similarly, the mean AED value and the mean ELCR value are higher than the world avarage values (UNSCEAR 2000).

Arin Lake and its surrounding area are a migratory route for migratory birds such as flamingos and songbirds. Furthermore, there are three villages located around this lake. Therefore, it is significant that the gamma dose value is higher than the world average. There could be several reasons for this elevation; however, the most crucial factor is believed to be the geological characteristics of Lake Arin, as it is located at the foothills of Mount Süphan, a volcanic mountain.

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Authors' Contributions

All authors contributed equally to the study.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The author declares that this study complies with Research and Publication Ethics.

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