Journal of the Nigerian Association of Mathematical Physics
Volume28, No. 1, (*November, 2014*), pp 213 – 222

Assessment of Background Gamma Radiation Within Geo Works Quarry Site In Igarra Akoko Edo Local Government Area Edo State Nigeria

Osahon O.D. and Abiola J.A.

Department of Physics, Faculty of Physical Sciences,
University of Benin, Benin City, Nigeria.

Abstract

Within and around major towns in Edo North, Edo State, Nigeria, there are scores of quarry industries whose activities constitute menace in the immediate environment. This study therefore assessed the level of natural background gamma radiation within a typical quarry sites located at Igarra the Headquarters of Akoko Edo Local Government Area, Edo State Nigeria. Measurement of background gamma radiation around the quarry site was carried out with Digital Geiger Counter GCA-07 model, calibrated with Cesium-137 (^{137}Cs) with a confidence interval of ±5% alongside with a calibrated digilert-50 nuclear radiation monitor. Measurements were made three times (morning, afternoon and evening) daily. Simultaneously, the ambient temperature and humidity were measured by means of an electronic thermo-hygrometer, model THC-20 manufactured by Shenzhen Tonglixing, China.

The results obtained show that the background gamma radiation ranged from a minimum of 12.50 cpm to a maximum of 18.00 cpm for GCA-07and from a minimum of 11.10 cpm to a maximum of 16.20 cpm for Digilert-50. The ambient temperature and humidity values were found to range from a minimum of 25.14°C to a maximum of 31.30°C and from a minimum of 52.7% to a maximum of 77.30% respectively. The mean radiation dose varying from 0.456 to 0.885 mSv/yr and 0.394 to 0.788mSv/yr for Digital Geiger Counter GCA-07 and Digilert-50 nuclear radiation monitor were compared with standard radiation dose limits of a body. The radiation dose values were found to be lower than the dose limit of 1mSv/yr in a normal background radiation environment according to the guidelines set out by the International Commission on Radiological Protection (ICRP) for all persons, other than those occupationally exposed. However, continuous exposure on the parts of the quarry workers and the farmers in the study area may constitute health hazards in the near future. Thus, regular monitoring of radiation level and determination of different types of radio-nuclides in the area is recommended in order to put in place appropriate measures and mechanisms that will serve as a check on the health and safety of the people.

Keywords: Background radiation, ambient temperature, count per minute, dose limit

1.0 Introduction

At all point in our existence, we are exposed to one form of radiation or the other. The range of radiation we are exposed to daily range from natural to artificially generated forms. The radioactive elements and their radiations are rather an indispensable part of nature. Their impact on living organisms is crucial and very vital to study [1].Often, radioactive materials with the characteristics of ionizing radiation are present in our environment both in nature, in living organisms as well as in our bodies. There are two sources of natural radiation in our environment: the Cosmos and the earth's crust. Cosmic radiation which comes from the sun and deep space coupled with radiation from the Earth's crust were actively effective before life began on Earth. Mankind developed and is continuously developing in a field of radiation. As it were, the presence of natural radioactive materials is inevitable. They can be found in construction materials, in the soil, air, food and drinking water, rocks, as well as in our body.Radon gas poses significant health concerns, and is the number two cause of lung cancer in the US behind smoking [2].Living things, precisely human owe their lives and health to man-made radiation. Medical and dental X-rays have been very vital in discerning hidden problems. Other forms of radiation have been used to diagnose and treat ailments with careful applications [3].Various tissues respond to radiation

Corresponding author: ***Osahon O.D.,*** E-mail: osahondavid@yahoo.com, Tel.: +2347064239787

differently. To characterize this non uniform sensitivity of tissues to radiation, we define the effective dose as the sum of the products of the equivalent doses ($H_{T,R}$) received by an organ times the tissue weighting factors (W_T) as shown in (Eq. 1.1) [4].

$$E = \sum(H_{T,R} \times W_T) \quad (1.1)$$

The sum of all the electrical charges (Q) of one sign produced by X- or gamma rays in a given mass (m) of dry air at standard temperature and pressure (STP) is referred to as the exposure, written mathematically as;

$$X = {}^{Q}/_{m} \quad (1.2)$$

2.0 Materials and Method

The background gamma radiation count per minute and dose rate were measured with the aid of the set up in Fig.1. In this study, two calibrated Geiger MÜller Counters and an Electronicthermo-hygrometer were used.

The Geiger counter GCA-07 with serial number 4134 was calibrated with Cesium-137 source calibrated with an HPGe detector for which the efficiency has been established with an IAEA traceable standard, with a confidence interval of ±5%. This equipment was used in the measurement of the background gamma radiation in count per minute and the dose rate in μSv/hr. Nuclear radiation monitor (also a Geiger MÜller counter) digilert-50 was also used to measure the background gamma radiation in count per minute. The Electronic thermo-hygrometer model THC-20 was used in determining the ambient temperature and the humidity in the study area.

The Geiger counter GCA-07, radiation monitor digilert-50 and the electronic thermo-hygrometer THC-20 were all placed on a platform 1.0 metre above the ground and close to the quarry machine that is used for the crushing of the quarry stones. The Geiger counter GCA-07 was set to count per minute and dose rate(in μSv/hr) modes while the radiation monitor digilert-50, was in count per minute mode only. The electronic thermo-hygrometer THC-20 was also placed and set to the mode of temperature and humidity measurements. All measurements were made in the morning, afternoon and evening respectively.

Fig. 1: Setup of the apparatus for measurement of background gamma radiation, temperature and humidity

Fig. 2: Geoworks quarry site

To convert the mean count rate to annual dose equivalent, (eq. 2.1)) is used [5].

1cpm = 0.0438 mSv/year (2.1)

3.0 Results and Discussion

The results obtained in this study are presented in Figures 3-10and Tables 1-6. The background gamma radiation levels around Geo-Works quarry site have been measured and values obtained show a relatively low level of background radiation. Figures 3-5 shows the stochastic nature of radioactivity. Figures 6-7 are the bar chart showing the count per minute for the different sections of this study for GCA-07 and Digilert-50 detectors while Figures 8-10 is a comparison of the cumulated activities for the two counters. The minimum and maximum mean count rate and dose rate for morning measurements were found to be 13.80, 17.50 and 0.1147μSv/hr, 0.1463μSv/hr respectively for Geiger counter GCA-07; 12.70, 15.40 and 0.0644μSv/hr, 0.0781μSv/hr respectively for Digilert-50 as shown in Table 1. Also the minimum and maximum mean count rate and dose rate for afternoon measurements were found to be 13.30, 15.00 and 0.1103μSv/hr, 0.1247μSv/hrfor Geiger counter GCA-07 respectively; 11.10, 16.20 and 0.0563μSv/hr, 0.0821μSv/hrfor Diligert-50 respectively as seen in Table 2. Finally, the minimum and maximum mean count rate and dose rate for evening measurements were found to be 12.50, 18.00 and 0.10380 μSv/hr , 0.1347 μSv/hr for Geiger counter GCA-07 respectively; 12.60, 15.40 and 0.0639μSv/hr, 0.0781μSv/hr for Digilert-50 respectively as also shown in Table 3. The cumulated activity for the GCA-07 and Digilert-50 over the entire period of the study shows a maximum activity of 185.20cpm and a minimum of 167.20 cpm as seen in Tables 4-6.

The Digital Geiger Counter GCA-07 recorded a maximum equivalent dose rate of 0.885mSv/yr and a minimum of 0.456 mSv/yr. Also, measurements from the Nuclear Radiation Monitor Digilert-50 gave a maximum equivalent dose rate of 0.788mSv/yrand a minimum of 0.394mSv/yr. These values when compared with the minimum set standards of 1 mSv/yr [6] for persons living in normal environment, the level of the background gamma radiation at Geo-Works quarry site is considered to be relativelylow. Also, the GCA-07 and the Digilert-50 respectively recorded a minimum amount of count per minute of 13.58 and 13.95, in the afternoon measurement. A maximum count per minute of 14.79 was observed for the GCA-07 in the morning session of the study, while the Digilert-50 gave a maximum value of 14.30 counts per minute in the Evening session.

The variations in both temperature and humidity for both equipments have been regularly normal, obeying an inverse relationship between the two parameters at different times of the day during the period of measurement. This relationship has been that of an increase in temperature resulting in a decrease in humidity and vice versa; with lowest temperatures being observed in the morning session and increases in that order till the evening session of the study period. In like manner, the humidity is highest in the morning session and decreases also in like manner till the evening session. The values of the count and dose rates where found to be independent of temperature, humidity and time of measurement during the day. This further confirms the fact that radioactivity is a random process. The variations in the dose rate are rather random and maybe attributed to factors like the activities of the quarry workers, the various materials at the quarry site emitting radiations in an irregular manner.

Also, it has been shown [7,8] that for a Geiger MÜller tube having a dead time t, the relation between the actual counting rate R and the correct counting rate R_0 is

$$R_0 = \frac{R}{1 - Rt} \qquad (3.1)$$

By applying equation 3.1 and using a dead time of 100μs for the two Geiger MÜller detectors, correct mean counting rate of between 11.1123cpm minimum and 18.1325cpm maximum were obtained in this study clearly shown in Table 7. These values when converted to annual equivalent dose rate resulted in values of 0.4867 mSv/year minimum and 0.7894 mSv/year maximum. These values of annual dose equivalent were found to be far lower when compared with the values obtained in the studies of regions like Chavara, Neendakara and Alappad [9] in india where background radiation levels ranges between 0.900 mSv/year minimum and 34.200 mSv/year maximum.

4.0 Conclusion

The background gamma radiation within Geo-works quarry site at Igarra in Akoko Edo Local Government Area has been determined using Digital Geiger Counter GCA-07 and Nuclear Radiation Monitor Digilert-50. The results obtained are shown in Tables 1, 2, 3, 4, 5, and 6. Doseassessment and other relevant values were determined for the site using data from both equipments. The minimum and maximum equivalent dose rates were obtained as 0.5475 to 0.7884mSv/year and 0.4862 to 0.7096mSv/year for GCA-07 and Digilert-50 respectively. The corrected minimum and maximum equivalent dose rates values are 0.5468 to 0.7883 mSv/year and 0.4857 to 0.7084 mSv/year for GCA-07 and Digilert-50 respectively. This results shows a level of background gamma radiation that is fairly lower than the 1 mSv/year internationally recommended standard for persons living in environment of normal background radiation [6].

Therefore we can conclude that activities at the quarry site in Akoko Edo Local Government Area of Edo State, Nigeria are more or less contributing minimal radiation level to the background radiation, and thus safe for workers at the site and residents around the quarry.

Table 1: Time, mean count rate, dose rate, mean temperature and average humidity morning measurement using Geiger Counter GCA-07 and Digilert-50.

	Time(minutes)	**Mean count rate (CPM)**	**Dose rate (μSv/ hr)**	**Mean Temperature** (℃)	**Average Humidity** (%)
Geiger Counter GCA-07	05.00	14.90±2.13	0.1238±0.0178	25.96	64.10
	10.00	15.70±2.08	0.1304±0.0174	25.59	66.90
	15.00	15.70±1.92	0.1306±0.0162	25.37	70.70
	20.00	16.30±2.36	0.1356±0.0195	25.23	74.00
	25.00	15.40±3.38	0.1280±0.0282	25.14	76.50
	30.00	16.50±5.98	0.1370±0.0499	25.16	77.00
	35.00	13.80±4.16	0.1147±0.0349	25.27	77.20
	40.00	14.00±2.55	0.1163±0.0213	25.39	76.60
	45.00	15.40±2.48	0.1280±0.0209	25.48	77.00
	50.00	14.70±1.52	0.1221±0.0127	25.54	77.20
	55.00	17.50±3.40	0.1463±0.0282	25.53	77.30
	60.00	15.30±1.04	0.1273±0.0087	25.49	77.30
Digilert-50	05.00	14.30±2.56	0.0725	25.96	64.10
	10.00	14.80±2.77	0.0750	25.59	66.90
	15.00	13.10±1.71	0.0664	25.37	70.70
	20.00	15.40±2.68	0.0781	25.23	74.00
	25.00	14.20±1.89	0.0720	25.14	76.50
	30.00	15.10±1.43	0.0766	25.16	77.00
	35.00	14.30±2.85	0.0725	25.27	77.20
	40.00	13.80±3.68	0.0700	25.39	76.60
	45.00	13.90±2.82	0.0705	25.48	77.00
	50.00	13.20±3.37	0.0625	25.54	77.20
	55.00	12.70±1.85	0.0644	25.53	77.30
	60.00	12.80±3.03	0.0649	25.49	77.30

Table 2: Time, mean count rate, dose rate, mean temperature and average humidity afternoon measurement using Geiger Counter GCA-07 and Digilert-50.

	Time(minutes)	**Mean count rate (CPM)**	**Dose rate (μSv/hr)**	**Mean Temperature** (℃)	**Average Humidity** (%)
Geiger Counter GCA-07	05.00	14.40±5.14	0.1196±0.0429	28.92	67.30
	10.00	13.40±1.98	0.1097±0.0152	28.73	67.60
	15.00	14.00±2.15	0.1164±0.0180	28.78	67.00
	20.00	14.60±2.88	0.1213±0.0240	28.75	66.70
	25.00	15.00±3.34	0.1247±0.0279	28.69	66.10
	30.00	13.30±2.08	0.1103±0.0173	28.75	65.00
	35.00	14.40±4.46	0.1197±0.0372	28.93	64.80
	40.00	14.10±2.36	0.1173±0.0195	29.02	64.00
	45.00	14.50±2.50	0.1204±0.0208	28.94	64.50
	50.00	14.50±4.47	0.1205±0.0374	28.99	64.10
	55.00	13.60±3.31	0.1130±0.0276	29.09	63.50
	60.00	15.00±2.03	0.1247±0.0169	29.10	64.00
Digilert-50	05.00	14.50±2.37	0.0735	28.92	67.30
	10.00	15.30±4.28	0.0776	28.73	67.60
	15.00	13.30±2.02	0.0674	28.78	67.00
	20.00	15.90±3.80	0.0761	28.75	66.70
	25.00	13.30±3.01	0.0675	28.69	66.10
	30.00	14.50±2.32	0.0735	28.75	65.00
	35.00	11.70±1.68	0.0593	28.93	64.80
	40.00	14.60±2.17	0.0750	29.03	64.00
	45.00	16.20±1.39	0.0821	28.94	64.50
	50.00	11.10±2.56	0.0563	28.99	64.10
	55.00	14.30±1.89	0.0725	29.09	63.50
	60.00	12.50±1.97	0.0634	29.10	64.00

Table 3: Time, mean count rate, dose rate, mean temperature and average humidity evening measurement using Geiger Counter GCA-07 and Digilert-50.

	Time(minutes)	Mean count rate (CPM)	Dose rate (μSv/hr)	Mean Temperature (℃)	Average Humidity (%)
Geiger Counter GCA-07	05.00	14.00±1.62	0.1164±0.0135	31.30	53.90
	10.00	18.00±3.59	0.1347±0.0298	31.05	52.80
	15.00	14.10±3.03	0.1171±0.0251	30.95	52.70
	20.00	14.60±3.60	0.1214±0.0299	30.79	52.70
	25.00	15.60±3.46	0.1297±0.0293	30.76	53.20
	30.00	13.90±2.72	0.1154±0.0226	30.80	53.60
	35.00	13.40±2.86	0.1113±0.0238	30.84	53.40
	40.00	14.60±1.78	0.1212±0.0149	30.78	53.90
	45.00	14.60±2.04	0.1213±0.0171	30.55	54.70
	50.00	15.00±3.71	0.1247±0.0308	30.48	55.50
	55.00	14.40±2.30	0.1197±0.0191	30.44	54.80
	60.00	12.50±2.72	0.1038±0.0228	30.31	54.70
Digilert-50	05.00	15.40±3.97	0.0781	31.30	53.90
	10.00	15.30±2.84	0.0776	31.05	52.80
	15.00	14.90±2.86	0.0775	30.95	52.70
	20.00	14.30±2.31	0.0725	30.79	52.70
	25.00	13.60±1.19	0.0689	30.76	53.20
	30.00	13.60±2.82	0.0689	30.80	53.60
	35.00	14.00±3.69	0.0710	30.84	53.40
	40.00	13.50±1.87	0.0685	30.78	53.90
	45.00	15.00±2.81	0.0711	30.55	54.70
	50.00	15.00±2.18	0.0761	30.48	55.50
	55.00	14.40±1.88	0.0730	30.44	54.80
	60.00	12.60±3.32	0.0639	30.31	54.70

Table 4: Cumulative Activity morning measurement for Geiger counter GCA-07 and Digilert-50

	Time(minutes)	Cumulative Activity (CPM)
Geiger Counter GCA-07	05.00	14.90
	10.00	30.60
	15.00	46.30
	20.00	62.60
	25.00	78.00
	30.00	94.50
	35.00	108.30
	40.00	122.30
	45.00	137.70
	50.00	152.40
	55.00	169.90
	60.00	185.20
Digilert-50	05.00	14.30
	10.00	29.10
	15.00	42.20
	20.00	57.60
	25.00	71.80
	30.00	86.90
	35.00	101.20
	40.00	115.00
	45.00	128.90
	50.00	142.10
	55.00	154.80
	60.00	167.60

Table 5: Cumulative Activity afternoon measurement for Geiger counter GCA-07 and Digilert-50

	Time(minutes)	Cumulative Activity (CPM)
Geiger Counter GCA-07	05.00	14.40
	10.00	27.80
	15.00	41.80
	20.00	56.40
	25.00	71.40
	30.00	84.70
	35.00	99.10
	40.00	113.20
	45.00	127.70
	50.00	142.20
	55.00	155.80
	60.00	170.80
Digilert-50	05.00	14.50
	10.00	29.80
	15.00	43.10
	20.00	59.00
	25.00	72.30
	30.00	86.80
	35.00	98.50
	40.00	113.10
	45.00	129.30
	50.00	140.40
	55.00	154.70
	60.00	167.20

Table 6: Cumulative Activity evening measurement for Geiger counter GCA-07 and Digilert-50

	Time(minutes)	Cumulative Activity (CPM)
Geiger Counter GCA-07	05.00	14.00
	10.00	32.00
	15.00	46.10
	20.00	60.70
	25.00	76.30
	30.00	90.20
	35.00	103.60
	40.00	118.20
	45.00	132.80
	50.00	147.80
	55.00	162.20
	60.00	174.70
Digilert-50	05.00	15.40
	10.00	30.70
	15.00	45.60
	20.00	59.90
	25.00	73.50
	30.00	87.10
	35.00	101.10
	40.00	114.60
	45.00	129.60
	50.00	144.60
	55.00	159.00
	60.00	171.60

Table 7: Actual and corrected counting and dose rate for Geiger counter GCA-07 and Digilert-50

ACTUAL COUNTING RATE					CORRECT COUNTING RATE			
	COUNT RATE (CPM)		DOSE RATE (mSv/year		COUNT RATE (CPM)		DOSE RATE (mSv/year	
	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
GCA-07	18.000	12.500	0.7884	0.5475	18.0325	12.5156	0.7894	0.5482
DIGILERT-50	16.200	11.100	0.7096	0.4862	16.2262	11.1123	0.7107	0.4867

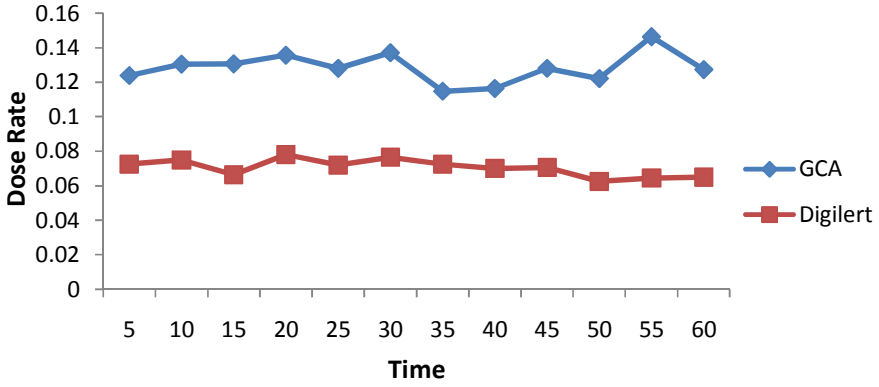

Fig. 3: Comparison of Dose rate for Geiger Counter GCA-07 and Digilert-50 for Morning measurement.

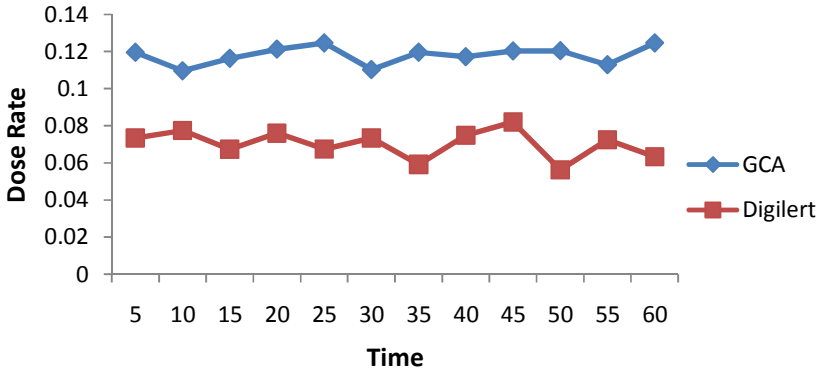

Fig. 4: Comparison of Dose rate for Geiger Counter GCA-07 and Digilert-50 for Afternoon measurement.

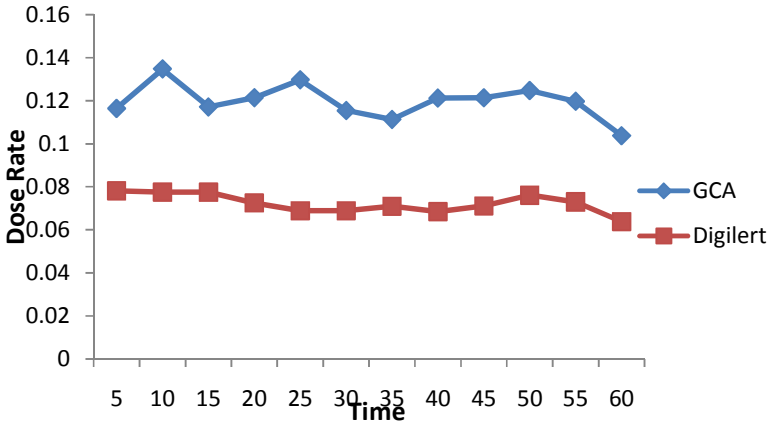

Fig. 5: Comparison of Dose rate for Geiger Counter GCA-07 and Digilert-50 for Evening measurement.

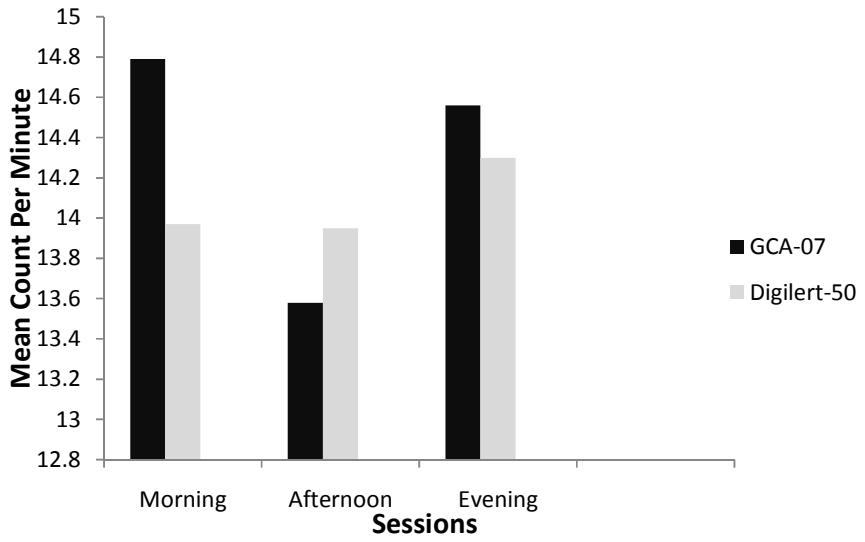

Fig. 6: Bar Chart showing Mean Count per minute for the different times of the day and for GCA-07 and Digilert-50.

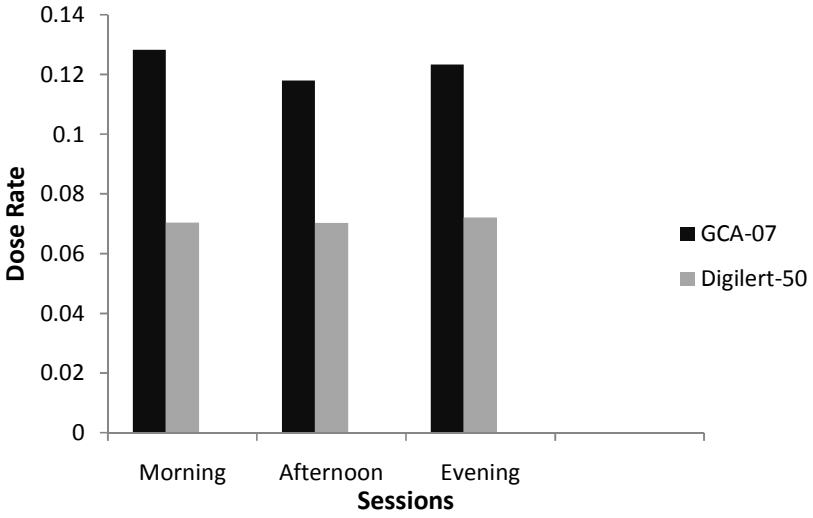

Fig. 7: Bar Chart showing the count per minutes for the different sessions of the work for GCA-07 and Digilert-50.

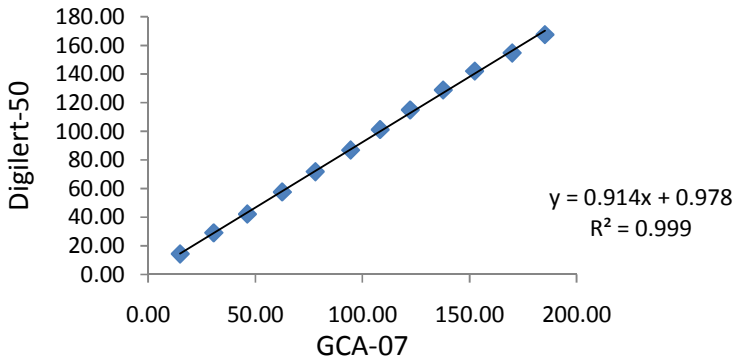

Fig. 8: Comparison of Cumulative Activity for Geiger counter GCA-07 and Digilert-50 for morning measurements.

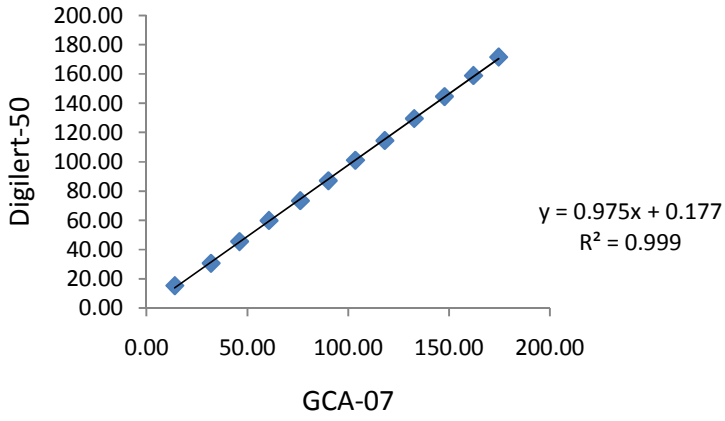

Fig. 9: Comparison of Cumulative Activity for Geiger counter GCA-07 and Digilert-50 for afternoon measurements.

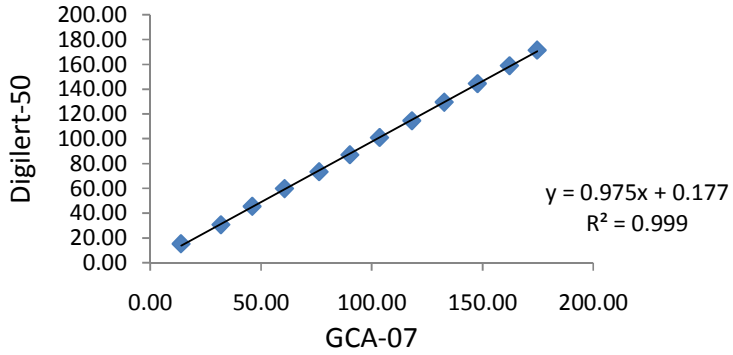

Fig. 10: Comparison of Cumulative Activity for Geiger counter GCA-07 and Digilert-50 for evening measurements

References

[1] Mishev A. and Hristova E. (2011): Gamma Background Measurements at BEO moussala. Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences 72 Tsarigradsko chaussee, Sofia 1284, Bulgaria.

[2] "Radon and Cancer, (2008): Questions and Answers". National Cancer Institute. Retrieved, 10-19.

[3] Washington State department of health. (2002): Background Radiation Natural versus man-made. Division of Environmental Health office of radiation protection.

[4] Lombardi M.H. (2006). Radiation Safety in Nuclear Medicine. Taylor and Francis Group, Boca Raton London New York.

[5] Osahon O.D (2013). Indoor measurement of background gamma radiation with height and ambient temperature within Edo State secretariat building, Benin City, Nigeria. Journal of the Nigerian Association of Mathematical Physics Vol. 24, 130-131.

[6] ICRP Publication 60 (1990). Recommendations of the International Commission On Radiatiological Protection. Annal of the ICRP 21

[7] Vasudeva A.S. (2010). Modern Engineering Physics Fifth Edition published by S. Chand and company Ltd Ram Nagar, New Delhi-110055.

[8] Burns D.M and MacDonald S.G.G (1970). Physics for Biology and Pre-medical Students second Edition. Addison-Wesley New York.

[9] Jayalekshmi P., Gangadharan P., Binu V.S., Nair R.R.K., Nair M.K., Rajan B. and Akiba S (2005). What did we learn from epidemiological studies in high background radiation area in India. Elsevier International Congress Series 1276 (102-105).