# EVALUATION OF BACKGROUND RADIATION IN RESIDENTIAL AREAS NEAR IIUM KUANTAN CAMPUS

**NORHANNA BINTI SOHAIMI, PhD (CORRESPONDING AUTHOR)**
DEPARTMENT OF DIAGNOSTIC IMAGING AND RADIOTHERAPY, KULLIYYAH OF ALLIED HEALTH SCIENCES, INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA, JLN SULTAN AHMAD SHAH BADER INDERA MAHKOTA 25200 KUANTAN, PAHANG, MALAYSIA
norhanna@iium.edu.my

**KASHFI BIN KHAIRUSALLEH**
DEPARTMENT OF DIAGNOSTIC IMAGING AND RADIOTHERAPY, KULLIYYAH OF ALLIED HEALTH SCIENCES, INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA, JLN SULTAN AHMAD SHAH BADER INDERA MAHKOTA 25200 KUANTAN, PAHANG, MALAYSIA
kashfikhairu06@gmail.com

**LAILA KALIDAH JUNET**
DEPARTMENT OF DIAGNOSTIC IMAGING AND RADIOTHERAPY,
KULLIYYAH OF ALLIED HEALTH SCIENCES, INTERNATIONAL ISLAMIC UNIVERSITY
MALAYSIA, JLN SULTAN AHMAD SHAH BANDAR INDERA MAHKOTA 25200 KUANTAN,
PAHANG, MALAYSIA
lailakalidahjunet@gmail.com

## ABSTRACT

**Introduction:** The purpose of this study is to monitor the amount of background radiation at residential areas near the International Islamic University Malaysia (IIUM) Kuantan Campus using optically stimulated luminescence dosimeter (OSLD). **Methods:** A total of 28 OSLDs were used in this study. The OSLDs were placed in seven residential areas near IIUM Kuantan Campus which were Indera Mahkota 2 (IM2), Indera Mahkota 6 (IM6), Indera Mahkota 8 (IM8), Indera Mahkota 15 (IM15), Astana Permai, Bukit Istana and KotaSAS with the duration of 18 days. Four OSLDs were placed at each residential area, three OSLDs were placed for 48 hours (2 days) whereas the remaining OSLD was left at the designated location until the 18th day as a control OSLD. microStar reader was used to read the OSLD and the results were analyzed using Microsoft (MS) Excel. **Results:** Generally, all seven residential areas near IIUM Kuantan Campus showed a steady increasing pattern of background radiation level. In the first cycle, Bukit Istana recorded the lowest value of background radiation which was -0.00244 mSv while Indera Mahkota 2 (IM2) recorded the highest background radiation with the value of 0.002038 mSv. For the last cycle, Indera Mahkota 15 (IM15) showed the highest reading of background radiation which was 0.016473 mSv whereas Indera Mahkota 8 (IM8) recorded the lowest value which was 0.010105 mSv. **Conclusions:** This study indicates that the background radiations in all seven residential areas near IIUM Kuantan Campus are within the recommended value for public exposure which is 1 mSv per year proposed by the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA).

**KEYWORDS:** Background radiation, Residential areas, OSLD

## INTRODUCTION

Background radiation is defined as any ionizing radiation that is present in the environment. It can originate from various sources either natural occurring background radiation or artificial (man-made). According to the Washington State Department of Health (2002), natural background radiation can be divided into three major sources which are terrestrial radiation, cosmic radiation and natural radioactivity in the body. Terrestrial radiation mainly comes from the soil as it contains radionuclides such as isotopes of uranium and thorium together with their decay products. Radon is one example of decay products which lead to both external gamma ray exposure and internal exposure from the inhalation of radon and its progeny. Usikalu, Akinyemi and Achuka (2014), explained that radionuclides such as potassium-40 ($^{40}$K) and the decay series of thorium-232 ($^{232}$Th) and uranium-238 ($^{238}$U) which are found in soil water and rock constitute mainly the natural radioactivity. According to Alzubaidi, Hamid and Abdul Rahman (2016), the amount of terrestrial radiation is related to the geological composition from which soils originate. Since most of building materials are made of geologic materials such as soil and rock, it also contributes to the natural background radiation level. External and internal radiation exposure can be caused by the presence of $^{232}$Th and $^{40}$K in building materials (Mohamed, Algamdi and Al-shamani, 2016).

In addition to that, the earth also receives constant radiation from the cosmic which derive from the sun and stars. Shahbazi-Gahrouei, Gholami and Setayendeh (2013) stated that cosmic radiation greatly depends on the altitude. This means that high altitude region receives higher cosmic radiation. Besides, human body also receives radiation from the natural radioactivity.. Radioactive isotopes such as $^{40}$K and carbon-14 ($^{14}$C), which are naturally present in the air, are incorporated into the food and then to the bodily tissues. On top of that, we are also exposed to man-made background radiation. Mostly, artificial background radiation comes from medical procedures such as diagnostic radiography and radiation therapy. Besides, industrial activity such as rare earth element processing could also produce background radiation. Other aspects such as consumer products, radioactive fallout and nuclear power could give rise to background radiation.

The main question that must be answered throughout this study is on the radiation safety issue of residential areas near the IIUM Kuantan Campus. This is because exposure to high radiation may cause long term health effects such as cancer . Kamiya et al. (2015) stated that radiation exposure increases the risk of cancer throughout life. In order to know the safety level of residential areas near IIUM Kuantan Campus, the background radiation level must be evaluated and then the results are compared with the dose limit recommended by the ICRP and IAEA. Since there is limited known published study about radiation in Indera Mahkota, the main purpose of this study is to gain knowledge about the safety of Indera Mahkota, particularly on radiation safety. Besides, the background radiation in Kuantan can be evaluated as well, since there is no study that has been conducted in Kuantan.

## METHODS

### OSLD preparation

The OSLD was handled according to the standard procedures. Before the OSLD can be used, it must be annealed for at least 24 hours. Then, the initial readings or pre-read for each OSLD were recorded in a table in dosimetry logbook. This was done to ensure the accuracy of the data. Each OSLD was labeled according to the venue of the placement and each designated location was represented by alphabet; from A until G. The OSLDs were coded with alphabets that represent the designated location. While for the control OSLDs, they were coded by adding alphabet ‘C’ after each representing alphabet. The labeling approach was done to avoid confusion and misplacement of the OSLD; hence reducing the data percentage of errors and incorrect analysis.

### OSLD placement and scheduling

Four OSLDs were placed at each venue for 48 hours per cycle. The total number of cycle in this study was six (6) cycles which were equivalent to a total of 288 hours. After 48 hours, three OSLDs for each designated location were collected while the other one was left in place. The OSLD that was left in place for 18 days without touching worked as a control. The purpose of the control OSLDs being remain in situ was to obtain the 18 days accumulated background radiation values. The first three collected OSLDs of each location were read using the OSLD reader to obtain the background radiation values that has been measured for the 48 hours. After the OSLDs were read, the same OSLDs were placed to the respective location as previously for the next 48 hours (second cycle) and the next cycle until all six cycles were completed.

### OSLD reading

The OSLDs were read using a microStar reader from Launder Company. The reader was connected via the USB cable to an external computer system containing the microStar software. A barcode scanner connected to the computer system was used to scan the barcode at the OSLD. The OSLD was then inserted into the microStar reader for the reading process.

### Data analysis

The OSLDs readings recorded from the microStar Software were exported and analyzed using the Microsoft (MS) Excel. The average of the background radiation readings per day and year were calculated. The sum of total background radiations per day and the percentage differences were obtained and were compared with the dose limit recommended by ICRP and IAEA.

For annual background radiation dose, the percentage difference with recommended dose limit by ICRP and IAEA for public is presented in Table 1. The annual background radiation dose in each residential area was calculated through Equation 1.

$$Annual\ Background\ Radiation\ Dose = \frac{Cumulative\ readings\ of\ background\ radiation}{18\ days} \times 365\ days$$

**Equation 1**

Meanwhile, the percentage difference of annual background radiation dose was obtained through Equation 2.

$$Percentage\ difference = \left(\left|\frac{Reference\ Value - Recorded\ Value}{(Reference\ Value + Recorded\ Value)/2}\right|\right) \times 100\%$$

**Equation 2**

## RESULTS

### Cumulative background radiation dose in seven residential areas near IIUM Kuantan Campus

The cumulative readings of background radiation in residential areas near IIUM Kuantan were displayed on Figure 1. Generally, all residential areas showed an increasing pattern in background radiation readings. The highest reading was recorded in Indera Mahkota 2 (IM2) whereas the lowest reading was recorded in Indera Mahkota 8 (IM8). However, the reading of background radiation in the last cycle in Indera Mahkota 15 (IM15) was the highest compared to other locations in the same cycle. Astana Permai and KotaSAS recorded almost the same readings of background radiation. Meanwhile, Indera Mahkota 6 (IM6) recorded a moderate value of background radiation.

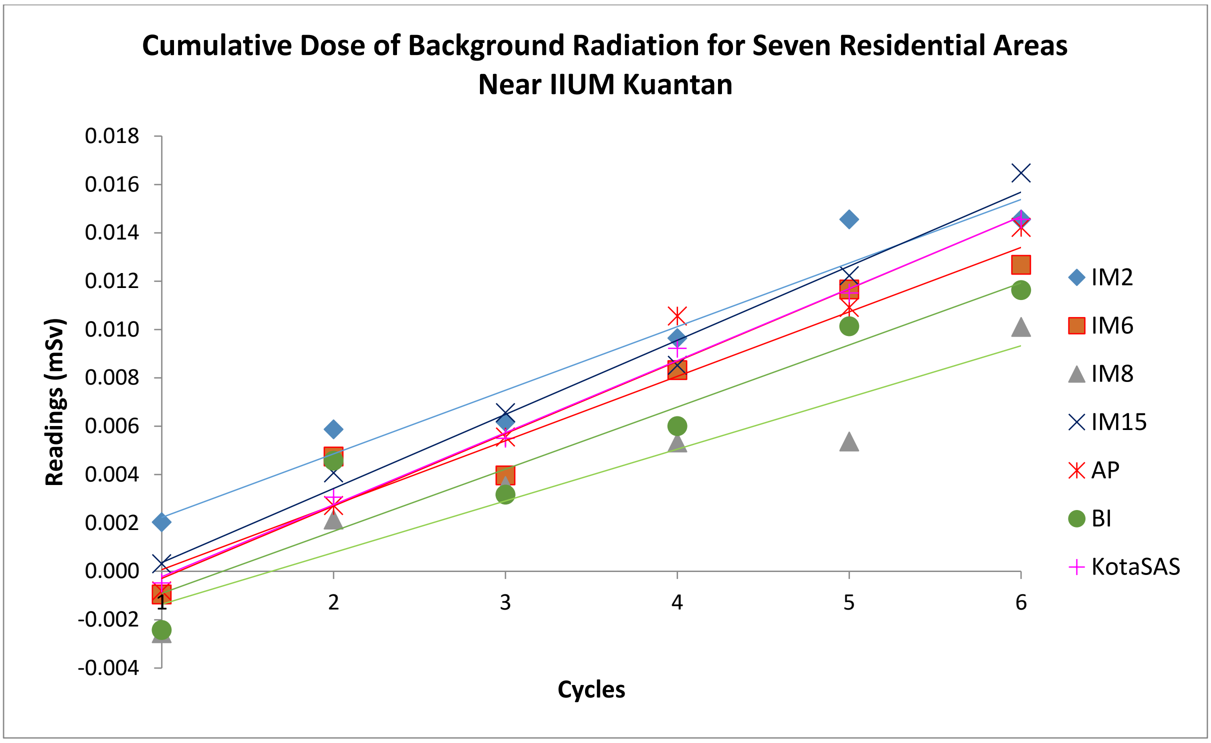

Figure 1: Cumulative dose of background radiation in residential areas near IIUM Kuantan Campus

### Comparison with Dose Limit Recommended by ICRP and IAEA for Public in Percentage Difference

Indera Mahkota 2 (IM2) recorded the highest percentage difference value which was approximately 126.00% followed by Bukit Istana with the value of 122.22% and Astana Permai which recorded an approximately 111.04% difference. Amongst all seven locations, Indera Mahkota 6 (IM6) recorded the median value of percentage difference which was 109.12%. There was only a small difference recorded between Indera Mahkota 8 (IM8) and Indera Mahkota 15 (IM15) with the value of 100.45% and 100.90% respectively. Meanwhile, the lowest value of percentage difference was recorded in KotaSAS with the value of 89.16%.

Table 1 Comparison with Dose Limit Recommended by ICRP and IAEA for Public in Percentage Difference

| Locations | Annual Background Radiation Dose (mSv/year) | Dose Limit Recommended by ICRP & IAEA for Public (mSv/year) | Percentage Difference (%) |
|---|---|---|---|
| Indera Mahkota 2 (IM2) | 0.227 | 1 | 126.00 |
| Indera Mahkota 6 (IM6) | 0.294 | | 109.12 |
| Indera Mahkota 8 (IM8) | 0.331 | | 100.45 |
| Indera Mahkota 15 (IM15) | 0.329 | | 100.90 |
| Astana Permai | 0.286 | | 111.04 |
| Bukit Istana | 0.241 | | 122.22 |
| KotaSAS | 0.383 | | 89.16 |

## DISCUSSION

### Geological and Geographical Aspect of Residential Areas near IIUM Kuantan

Although it is not a strong inference, the geology aspect of the residential areas must be taken into account as the influencing factor of background radiation level since the geology aspect of residential areas is different with each other. The highest increment of background radiation was recorded from KotaSAS and Indera Mahkota 8 (IM8) with the value of 0.0189 mSv and 0.0163 mSv respectively, while the lowest increment was recorded from Indera Mahkota 2 (IM2) with the value of 0.0112 mSv. Both KotaSAS and Indera Mahkota 8 (IM8) are located near the forestry area whereas Indera Mahkota 2 (IM2) is situated at a flat or low land area. The soil from the forestry areas is considered to have higher background radiation level. This is because that this area is rich with acid or basic intrusive geological features. According to Bakar, Hamzah and Saat (2017), soil from acid intrusive has higher concentration of $^{226}$Ra, $^{232}$Th and $^{40}$K. The background radiation levels for Indera Mahkota 6 (IM6), Indera Mahkota 15 (IM15), Astana Permai and Bukit Istana were recorded as in moderate level compared to other locations.

The earth also received constant cosmic radiation which is greatly depends on the altitude of the area. According to Shahbazi-Gahrouei, Gholami and Setayendeh (2013), higher altitude affects the natural background radiation from the sun which will contribute to high potential getting radiation. Referring to Figure 2, Astana Permai has the highest elevation which is 45 meter above the sea level. However, the increment of background radiation in Astana Permai was only 0.0141 mSv which is lower compared to KotaSAS. KotaSAS recorded the highest increment in background radiation with the value of 0.0189 mSv at only 26 meter above the sea level. Although Indera Mahkota 15 (IM15) is situated at the same elevation with KotaSAS, the increment of background radiation is lower with the value of 0.0162 mSv. This might be due to the location of KotaSAS that was developed near to the forestry area. Indera Mahkota 6 (IM6) was developed on a more flattened area with the elevation of only 16 meter but the increment of background radiation was noted to be 0.0145 mSv. This is slightly higher compared to Indera Mahkota 2 (IM2) which was developed at higher elevation area and recorded only 0.0112 mSv increment of background radiation reading. These findings contradict with the study conducted by Pinilla, Asorey and Nunez (2015) which found that the background radiation level at the higher altitude is higher compared to lower altitude region. Hence, it could be suggested that altitude might not be a significant influencing factor of background radiation level.

Figure 2 Topography map of residential areas near IIUM Kuantan Campus.

### Composition of Building Materials

According to Abo-Elmagd, Saleh and Afifi (2017), the soil and building materials are the examples of major sources of indoor radon.Shoeib and Thabayneh (2014) demonstrated that cement bricks has the highest concentration of $^{226}$Ra. Radon is actually the decay products of $^{226}$Ra. This may be the factor that contributes to the level of background radiation in residential areas. However, it is hard to conclude that whether radon in building materials is the major source of background radiation in the stated residential areas. This is because the OSLD that had been used could not differentiate the energy spectrum of the background radiation. It only recorded the overall dose value of background radiation. A specific detector must be used to evaluate the amount of radiation produced by radon.

### Comparison of Background Radiation Level with Dose Limit Recommended by ICRP and IAEA

In this study, the percentage differences that show the highest percentage would mean that the background radiation has way far lower dose compared to the annual dose limit recommended by the ICRP and IAEA. It is shown by IM2 where the annual background radiation dose is lowest (0.227 mSv) compared to others with the percentage difference of 126%. The lower percentage means that the background radiation dose is closer to the dose limit recommended by the ICRP and IAEA as shown by KotaSAS (0.383 mSv); which recorded as the highest annual background radiation dose compared to others with the percentage difference of 89.16%.

## CONCLUSION

This study indicates that the background radiations in all seven residential areas near IIUM Kuantan Campus are within the recommended value for public exposure which is 1 mSv per year as proposed by the ICRP and IAEA. Hence, it can be concluded that all residential areas near IIUM Kuantan Campus are safe for the public.

## ACKNOWLEDGEMENT

This research was supported by the Research Initiative Grant Scheme (RIGS) 2016 (RIGS 16-133-02970), Research Management Centre, IIUM. We also thanked our colleagues from the Department of Diagnostic Imaging and Radiotherapy, KAHS and all parties involved in providing insight and expertise that greatly assisted the research.

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