ASSESSMENT OF BACKGROUND RADIATION IN SPORT AND RECREATIONAL PLACES IN KUANTAN

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ABSTRACT

Introduction: The purpose of this study is to assess the background radiation level (BRL) in seven sport and recreational places in Kuantan district whether it is within the acceptable limit stated by radiation protection regulatory bodies. There has never been research done to assess the BRL in the sport and recreational places in Kuantan by using optically stimulated luminescence (OSL) dosimeter. **Methods:** Reading of BRL was monitored using Inlight Environmental Dosimeter. Seven sport and recreational places inside Kuantan district were identified and located as venues for location of study. Data was collected at the designated locations for seven cycles where one cycle consists of seven days. Readings from OSLDs were taken at the end of each cycle and analyzed using Landauer microStar computer system. All background radiation doses for each designated area were also compared with the recommended value by radiation protection regulatory bodies such as IAEA, NCRP and AELB**. Results:** The accumulated BRL shows trend of increasing level of background radiation over the seven cycles. The highest annual dose reading was noted in Stadium Hoki Wisma Belia with a reading of 2.286 mSv. The lowest annual dose was at Futsal Playground with a reading of 1.321 mSv. **Conclusion:** The accumulated dose calculated to represent estimated annual BRL of the designated places exceeded the recommended value of background radiation for public (1 mSv per year) from radiation regulatory bodies; ICRP, AELB and IAEA. Comprehensive monitoring of the designated locations must be done to ensure the safety of the surroundings. However, there are some possible influencing factors that can affect the results such as geographical, types of building materials used and infrastructure development. This study suggests that this study to be continued for a longer study period to obtain more reliable results in order to construct a platform for environmental radiation monitoring in Malaysia.

KEYWORDS: Background radiation, public exposure, Ionizing radiation, Natural source of radiation, Effect of background radiation, Annual dose limit

INTRODUCTION

Background radiation is in invisible form and can cause harm to human health. Turner (1998) reported that too much exposure to sunlight may cause cutaneous malignant melanoma and non-melanocytic skin cancer. Moreover, a fact stated by the National Council on Radiation Protection and Measurements (NCRP) in 2009 that the largest source of human made exposure or dose is from medical testing and treatment. However, study done by United States Environmental Protection Agency (US EPA) in 2012 stated that, radon (which is naturally available radioactive materials) causes an estimated 20000 lung cancer death each year. This finding is also supported by Mishra, Sapra, and Mayya (2014), that concluded increasing mortality is closely related to the high background radiation area.

The complex relationship between cancer and background radiation supports the need for environmental surroundings monitoring to increase the awareness among the public regarding risk of ionising radiation. There are many types of radiation monitoring devices, also known as dosimeter that are capable of measuring low dose measurement with respect to background radiation. One of the recent popular dosimeter is the Optically Stimulated Luminescence dosimeter (OSLD). Medeiros and de Alencar (2013), emphasized that OSL dosimetry has become a successful technique in personal and environmental dosimetry due to high luminescence efficiency, excellent reproducibility, and fast readout signal. Environmental OSLD can detect all the alpha, beta and gamma radiation present in the surrounding.

Physical activity plays an important role in leading a healthy and balanced lifestyle. Mentioned by Deputy Minister of Tourism and Culture Malaysia Datuk Mas Ermieyati (2017), sport and recreation should be a fundamental part of the lives. Most of the sport and recreational places are designated outdoor, hence people have a high chance to be exposed to sunlight. Sunlight is the form of ultraviolet (UV) light and one of the ionising radiation sources (World Health Organization [WHO], n.d.).

A study done by US EPA (2010), stated that people who spent a lot of time under the sun has higher risk of getting skin cancer, cataracts, suppression of immune system, and premature aging of the skin. Sport and recreational places that exposed to high background radiation might increase the risk of cancer to the visitors. There was limited research done to assess the level of background radiation (BRL) in the sport and recreational places in Kuantan by using OSLD. Therefore, it is necessary to monitor the environmental surroundings in Kuantan, in order to have the safe conditions for leisure activity.

METHODS

Design of Study

This was an experimental study done with seven chosen sports and recreational places available in Kuantan, Pahang: Futsal Taman Polo, Stadium Hoki Wisma Belia, Stadium Darul Makmur, Esplanade, Taman Gelora, Teluk Cempedak, and Futsal Playground.

Optically Stimulated Luminescence Dosimeter (OSLD)

InLight Environmental Dosimeter by Landauer, Inc. was chosen as OSLD for the data collection. The material used in this dosimeter was Al_2O_3 as the layer of detector element for detecting four types of doses namely deep dose, lens dose, shallow dose and beta dose.

Table 1: D**etection capabilities of InLight Environmental Dosimeter**

Types of radiation	Range of energies detected
Photons (X and gamma rays)	Energies above 15keV nominally: 1mrem to 1000 rem
Beta particles	Energies greater than 500 keV average energy: 20 mrem to 1000 rem

Preparation and Labelling of OSLD

Before process of OSLD placement, the OSLDs were annealed using white light. This standard of procedure was done at least one day before the OSLD placement. OSLDs were placed inside plastic zippers as protective measure to prevent any damage caused by dirt or water during the placement of OSLDs. The front of plastic zippers was labelled with code numbers representing the designated places. All annealed OSLDs were placed inside a lead container to prevent exposure to external radiation that will contaminate and interfere to the reading value. The bar code of the OSLD was noted according to the designated places to make sure that the same OSLD was used at the same places throughout seven weeks of data collection.

Placement of OSLD at Designated Places

The labelled OSLDs with designated place were carefully placed at a suitable position after considering the possible external factors that might cause damage to the OSLDs. There were seven cycles of data collection throughout the experiment. One cycle consists of seven days. On the first day, the OSLDs were prepared and placed inside the lead container then brought to designated places for placement. Then the OSLDs were left for six days. The collection of OSLDs were done on the seventh day of the cycle and brought to Diagnostic Imaging Laboratory in KAHS, IIUM for reading purposes using the InLight microStar system.

Data Analysis

All the data generate in the microStar system was sync and converted to Microsoft Excel format for analysis purposes. Details extracted from the data and visualized in Microsoft Excel were actual dose per week, cumulative dose and annual dose. The background radiation doses in the designated area were also compared with the recommended value by radiation protection regulatory body such as IAEA, AAPM and AELB.

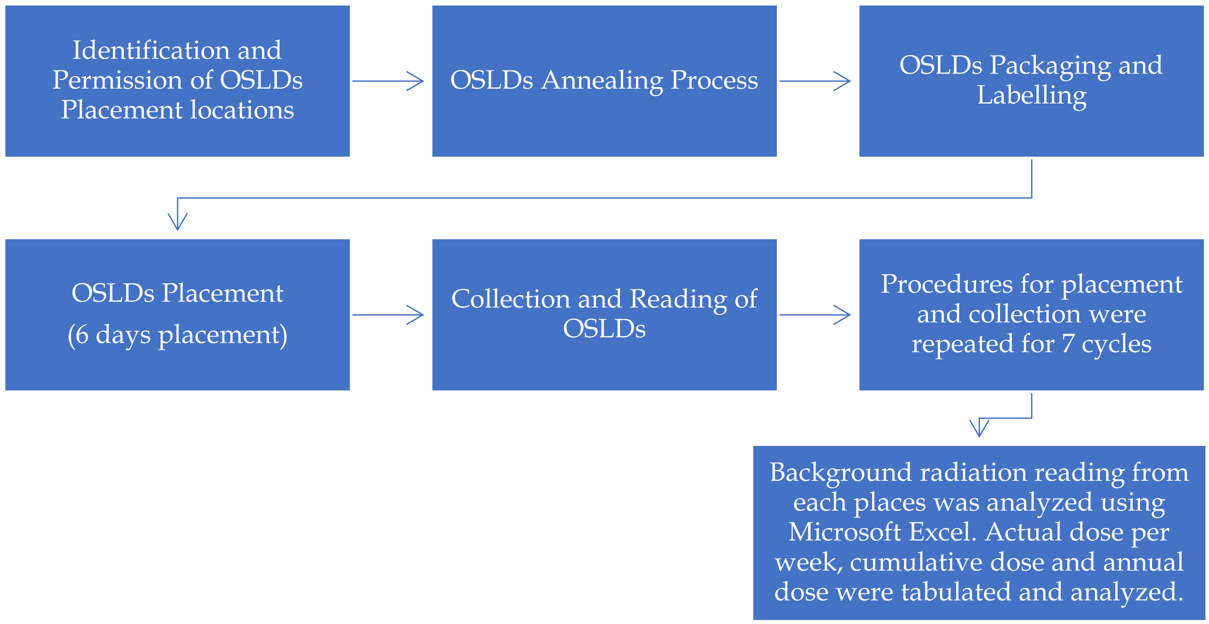

Figure 1: The Flow of OSLDs procedure.

Figure 1 shows the flow of procedure throughout the study for seven cycles. The procedures include pre-data collection, during data collection and post data collection.

RESULTS

Different windows in the OSLD give out different values according to the types of radiation detected. Deep dose refers to penetrating energy from gamma or x-rays. Shallow dose refers to low energy and less penetrating radiation such as beta and low energy x-rays. Lens dose refers to the intermediate range of radiation energy. In this study, deep and lens dose represent the cumulative dose whereas shallow and beta dose are not detected.

Accumulated Background Radiation Dose in Different Sport and Recreational Locations in Kuantan

The accumulated background radiation level (BRL) shows an increasing trend in BRL over the seven cycles as shown in Figure 2. The highest cumulative dose reading was recorded in Stadium Hoki Wisma Belia on the seventh cycle with a reading of 0.263 mSv. The lowest cumulative deep dose on the seventh cycle was at Futsal Playground with a reading of 0.152 mSv. The recorded cumulative doses for all designated places were different starting in Cycle 2 until Cycle 7 although the initial values (Cycle 1) were relatively similar. The differences in the recorded values are probably influenced by several factors such as geographical factors and infrastructure development factors.

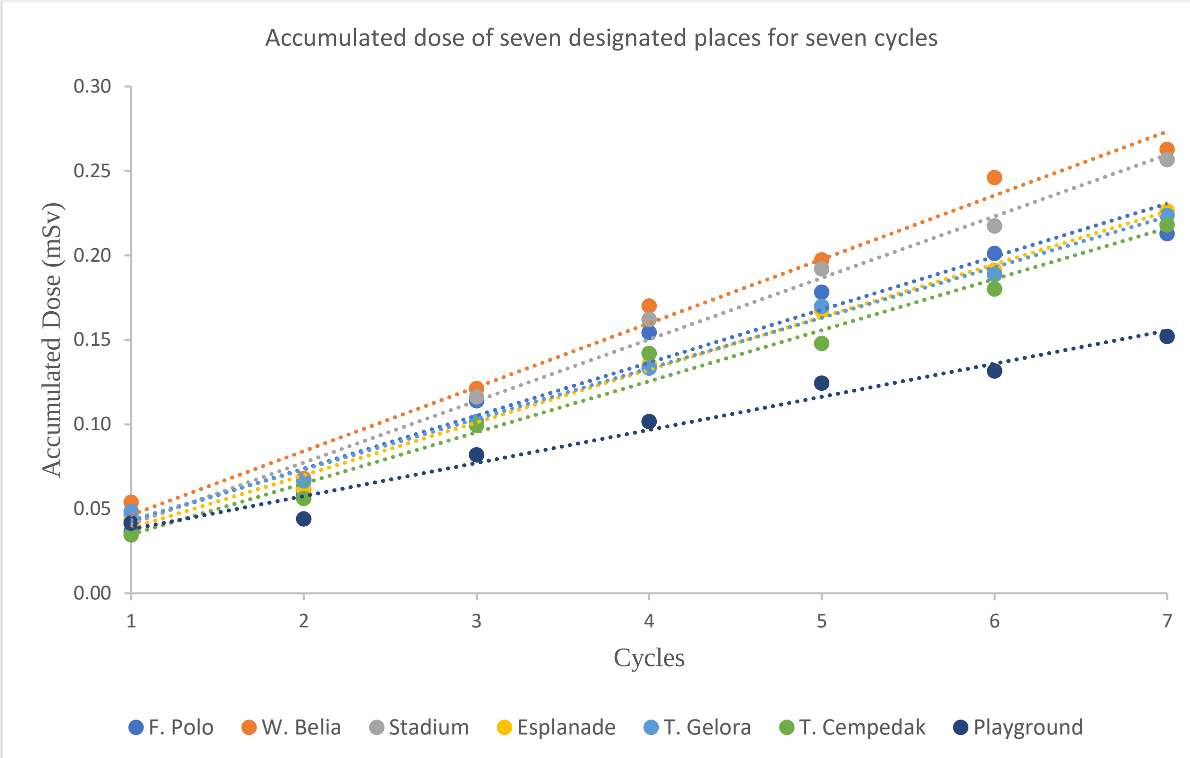

Figure 2: Accumulated dose of seven designated places for seven cycles.

Comparison of Estimated Annual Dose with Recommended Background Radiation Guideline for Public by Radiation Regulatory Bodies

Cappelan and Unhjem (2009) highlighted the recommended public and non-occupational exposure limit by International Commission on Radiological Protection (ICRP) of 1 mSv per year. The same recommended value was also highlighted by Atomic Energy Licensing Board (AELB) in "Code of Practice on Radiation Protection of Non-Medical Gamma & Electron Radiation Facilities" published in 2008.

For the comparison purposes, the background radiation level (BRL) obtained in this study was calculated and converted to the estimated annual dose value. The estimated annual dose was calculated by using simple equation based on the time of the OSLD placement; the cumulative actual dose was divided with days of placement and then multiplied with 365 days occupied in a year. The estimated annual dose and the percentage differences with the recommended value for each location were tabulated in Table 3. The percentage difference between the readings obtained and the value from radiation protection regulatory bodies was calculated using the following formula:

$$\textbf{\textit{Percentage Difference}} = |V_1 - V_2| / (V_1 + V_2/2) \times 100$$

$\mathbf{V_1}$= Estimated Annual Dose of a designated location
$\mathbf{V_2}$= Annual Dose recommended by radiation regulatory body

Table 3 Comparison of estimated annual dose with recommended background radiation guideline for public by radiation regulatory bodies

Location	Estimated Annual Dose (mSv/year)	Recommended annual public dose by ICRP, AELB and IAEA (mSv/year)	Percentage Difference %
Futsal Polo	1.851		59.70
Stadium Hoki	2.286		78.27
Stadium Darul Makmur	2.233		76.28
Esplanade	1.964	1.0	65.05
Taman Gelora	1.947		64.27
Teluk Cempedak	1.895		61.83
Futsal Playground	1.321		27.66

DISCUSSION

Throughout the study, readings obtained in lens and deep windows from the OSLD were the same. There were no differences of reading between all seven designated places. Supposedly, these two windows are able to differentiate two different types of radiation energy, high penetrating energy from gamma or x-rays and intermediate radiation energy. According to the Landauer specialist, this situation is due to the presence of radiation with high energy peak but low in radioactivity. Therefore, due to these conditions, the background radiation values for both windows in the OSLDs recorded the same value.

The two locations with the highest cumulative actual deep dose reading were Stadium Hoki Wisma Belia (3.8274° N, 103.2825° E) and Stadium Darul Makmur (3.8149° N, 103.3238° E) with reading of 0.263 mSv and 0.257 mSv respectively. Both places were surrounded with tall and big buildings. Nearby Stadium Hoki Wisma Belia exists a huge swimming pool centre, big restaurant building and massive convention centre. Stadium Darul Makmur was in the centre of Kuantan city with tall buildings around it. The surrounding factors (development of infrastructure) contribute to higher probability of high background radiation level detection as the building materials are one of the radiation potential sources. The type of raw material or industrial waste used for building material production determines the radioactivity of building materials (Mustonen, Pennanen, Annanmaki & Oksanen, 1997). Thus, this geographical setting may have contributed to the reading obtained from the OSLD.

The existence of several influencing factors can be related to the findings of estimated annual dose for background radiation in sports and recreational places Kuantan, Pahang that exceeded the recommended guideline for public by radiation regulatory bodies. The first factor is geographical factor. According to a study done by Ramachandran (2011), the cosmic ray dose rates increase as the altitude increases. This explanation is applicable for Esplanade, Teluk Cempedak and Taman Gelora where the annual dose from these locations is almost identical (1.964 mSv, 1.895 mSv and 1.947 mSv respectively) reflecting the almost similar elevation above sea level (2m, 7m and 8m respectively). Futsal Playground and Futsal Taman Polo were expected to have the highest annual background dose with elevation from sea level of 26m and 31m respectively. However, these two locations had the lowest annual dose (1.321 mSv and 1.851 mSv respectively) compared to the other designated locations. Therefore, the geographical factor (elevation above sea level) was not applicable for these two locations.

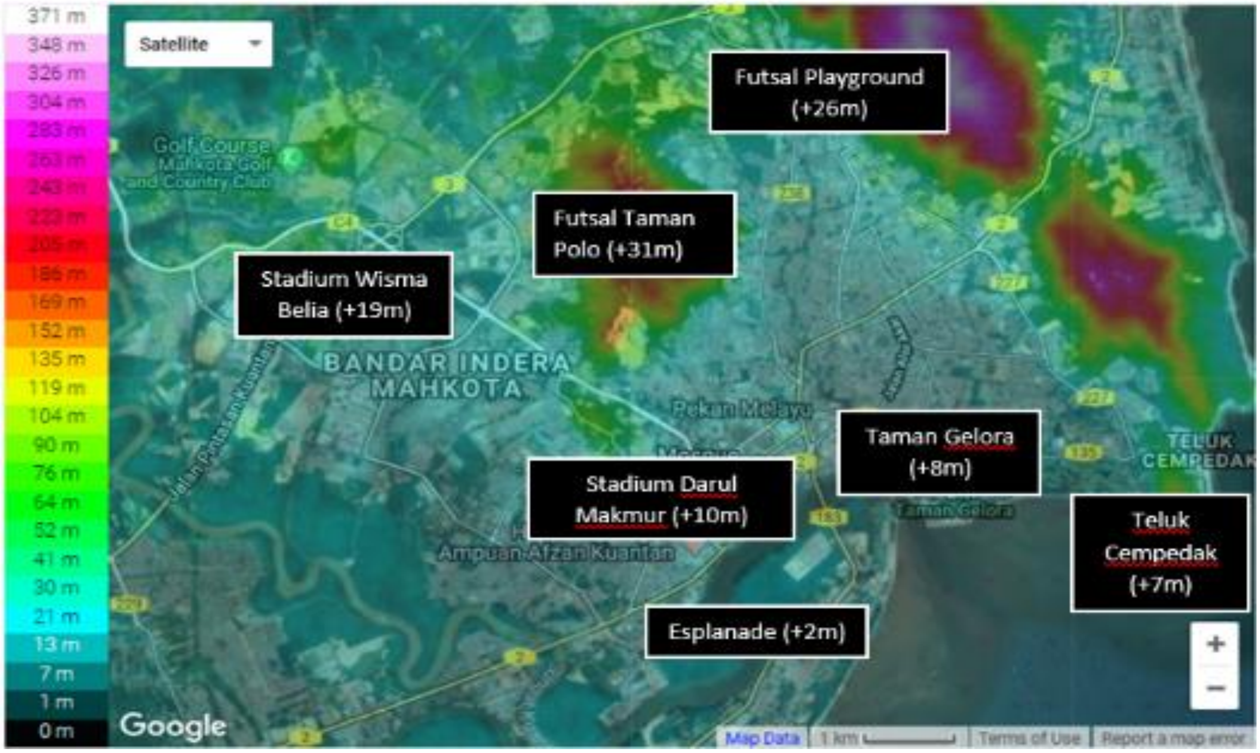

Figure 3: Topographic map of designated sport and recreational places in Kuantan, Pahang.

High estimated annual background radiation dose from Stadium Hoki Wisma Belia (2.286 mSv) and Stadium Darul Makmur (2.233 mSv) indicate that there are other influencing factors such as development of infrastructure and building materials that were affecting the reading of OSLDs at these locations. Besides natural rocks and soil, it can be identified that the difference in readings from all designated places were due to difference in content of materials presence in the building materials and the nature of the building itself. Increment of the aerial outdoor gamma dose rate by about 35% is due to the building materials instead of soils and rocks (Medeiros & Yoshimura, 2005). This statement suggested that the building materials in the location such as Stadium Hoki Wisma Belia and Stadium Darul Makmur may consist of materials that can emit radiation. In fact, these materials in the end may have contributed to the liberation of radiation gases that affect the reading of the OSLDs. The level of background gamma radiation in urban places is not only dependent on the type of building materials but also on the thickness of a layer of the building materials.

CONCLUSION

The measurement of background radiation in designated places recorded the different levels of deep dose readings and showed increasing trend throughout seven cycles representing accumulated dose. The highest annual dose reading was in Stadium Hoki Wisma Belia (2.286 mSv) and the lowest was at Futsal Playground (1.321 mSv). The estimated annual dose of the designated places exceeded the recommended value of background radiation for public (1 mSv per year) from radiation regulatory bodies; ICRP, AELB and IAEA. Some possible influencing factors are geographical, types of building materials and development of infrastructure. However, the findings in this study only recorded the background radiation dose for a short duration and only reported the estimated annual dose. Therefore, it is suggested that this study to be continued for a longer study period to obtain more reliable results and can be used as a guideline as well as platform for environmental radiation monitoring in Malaysia.

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