DETECTION OF BACKGROUND RADIATION USING OPTICALLY STIMULATED LUMINESCENCE (OSL) DOSIMETER IN PUBLIC SCHOOLS IN KUANTAN, PAHANG

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ABSTRACT

Introduction: The objective of this paper is to measure the background radiation using optically stimulated luminescence (OSL) dosimeter in various public schools in Kuantan, Pahang and to compare the results with recommended value provided by regulatory bodies. Few researches relating to background radiation monitoring is done using OSL as the main dosimeter. **Methods:** Monitoring of background radiation level is obtained using NanoDot OSL dosimeters. Eight schools in Kuantan were randomly selected and chosen for the location of study. Post guard and assembly areas were chosen as location of OSLD placement. Data was collected within five cycles in which each cycle took about 48 hours of exposure. Data obtained is then analysed using Landauer microStar computer system. Amount of background radiation level is then compared with annual effective dose limit provided by regulatory bodies such as AELB, IAEA and ICRP. **Results:** The accumulated background radiation level in both post guard area and assembly area showed increasing pattern during period of data sampling. The highest annual dose in post guard area is found in SK Cenderawasih with the value of 1.3283 mSv per year while the lowest annual dose is found in SMK Alor Akar with 0.5459 mSv per year. The highest annual dose in assembly area is noted in SK Semambu with a value of 1.1980 mSv per year while the lowest reading is noted in SMK Tengku Panglima Perang Tengku Muhammad with 0.5100 mSv per year. The recommended annual dose value by ICRP is 1 mSv per year for public. **Conclusions:** Several factors can influence the reading of background radiation level which includes geographical factors, building materials and surrounding environments. The background radiation levels in majority of schools do not exceed the recommended limit. The researchers suggested this study should be continued and involve all schools in Malaysia in order to monitor the background radiation level as well as to provide safe environment to our future generation.

KEYWORDS: Background radiation level, School, Kuantan, OSLD.

INTRODUCTION

Natural background radiation is a radiation that present in the environment and the major source of human exposure to low-level ionising radiation (Hendry et al., 2009). According to the report by Ahmad, Jaafar, Bakhash and Rahim (2014), the awareness of background radiation among Malaysian are slowly increasing in recent years. This report stated that there were numerous studies that have been conducted involving the measurement of natural background radiation in different regions of Malaysia from 1994 until 2014.

The natural background radiation is emitted from a variety of natural and artificial sources (Nanto, Takei and Miyamoto, 2011). The Earth's crust itself is filled with natural radioactive sources. According to Shahbazi-Gahrouei, Gholami and Setayandeh (2013), it is estimated that 82% of human-absorbed radiation doses, comes from natural sources such as cosmic, terrestrial and exposure from inspiration or intake of radiation sources. Natural background radiation poses some risk to human health. Mahur, Kumar, Sengupta and Prasad (2009), stated that the natural background radiation could possibly cause lung cancer. In addition, cancer has become one of the main health problem in Malaysia. Ahmad et al. (2015) explained that cancer has been identified to be one of the major cause of death and this finding has become an important concern in public health. Furthermore, natural background radiation can be measured by a measuring device or dosimeter known as optically stimulated luminescence (OSL). The OSL has better sensitivity and has high reproducibility. Pradhan, Lee and Kim (2008) stated that OSL has good efficiency and provides a possibility of repeated readout. In addition, study done by Menon et al. (2013), shows that OSL dosimeter gave an accurate measurement for background radiation monitoring. Thus, OSL is chosen as the main dosimeter for this study.

A study done by Ahmad et al. (2014) has compiled all the radiation monitoring study conducted in Malaysia since 1994 until 2014. According to this study, the number of researches done relates to background radiation monitoring were few especially in East Coast of Malaysia and there is no research has been done using OSL as the main dosimeter. Among the public areas in Kuantan, there are a lot of public schools scattered across the city ranging from primary schools, secondary schools to boarding schools. However, until today there is no evidence shows a research or study of background radiation has been conducted in Kuantan's public schools. The public schools mainly comprised of students which are from the younger generation. These young generation, which are pre-schoolers until teenagers have higher radiation risk due to their rampant growth of cell differentiation and proliferation (National Research Council, 1990). Thus, they have higher tendency to develop illness or mutations due to radiation exposure. Moreover it is mentioned by Spycher et al. (2015) that background radiation may contribute to the risk of cancer in children. Because of that, it is imperative to ensure the environment radiation level is safe for the students and public. Therefore, this study aims to identify the amount background radiation presents in a number of schools chosen in Kuantan.

METHODS

Study design

This study was an experimental study where it aimed to determine the amount of background radiation using optically stimulated luminescence (OSL) dosimeter in various public schools in Kuantan, Pahang. The data collected was analysed and compared with the standard recommended value by national and international agencies.

Study location

The study was conducted in eight different schools around the region of Kuantan, Pahang which include; 1) Sekolah Menengah Kebangsaan Tengku Panglima Perang Tengku Muhammad, 2) Sekolah Berasrama Penuh Integrasi Kuantan, 3) Sekolah Kebangsaan Cenderawasih, 4) Sekolah Kebangsaan Sultan Abdullah, 5) Sekolah Menengah Agama Al-Ihsan, 6) Sekolah Menengah Air Putih, 7) Sekolah Menengah Alor Akar and 8) Sekolah Kebangsaan Semambu.

Methodology

Approval to conduct study
The approval to conduct research was obtained through KAHS Kulliyyah Postgraduate Research Committee (KPGRC). Then, the approval from the Ministry of Education was obtained through Educational Research Application System (eRas). Following that, approval from Jabatan Pendidikan Pahang (JPP) is obtained. Lastly, the approval from the headmasters or principals of each school was obtained by direct approach to office of each school.

Preparation of OSLD
Annealing of OSLD were done prior to data collection. Then, the dosimeters were read in the lab using OSL dosimeter reader to obtain the pre-read value. Following that, the dosimeters were placed and encapsulated within a folded black paper and placed inside a small thin layer of plastic bag. Each plastic bag is labelled according to the location of placement.

Placement of OSLD
The total duration of data sampling was 15 days which includes five cycles of data collection. The total hours for each cycle were 48 hours. After 48 hours, the dosimeters were collected and read. The following day, the OSL dosimeters are brought back to prepare for the next cycle of data collection. Two specific locations were chosen in the school. The first place was the post guard area of the school while the second place was the assembly area of the school. These locations were chosen because both areas were classified as the common area for the student to gather and less influence by radiation from other factors such as building materials. Six OSLDs were used for each school. Three OSLDs including the control were placed in the post guard area while the remaining three were placed in the assembly area. The purpose of the control here was to measure the total background radiation for 15 days. Table 1 showed the schedule for the five cycles of data sampling and collection.

Table 1: Schedule for OSLD placement

Cycle	Date
C1	11th April 2018 – 13th April 2018
C2	14th April 2018 – 16th April 2018
C3	17th April 2018 – 19th April 2018
C4	20th April 2018 – 22nd April 2018
C5	23rd April 2018 – 25th April 2018

Data reading and recording

The reading of each OSL dosimeter was done using InLight MicroStar reader computer system from Landauer Company, France. The value obtained were already corrected by the software system as followed;

$$\text{Reading (mSv)} = \frac{\text{PMT Signal}}{\text{Sensitivity} \times \text{Calibration Factor}}$$

The reading obtained were analysed using Microsoft Excel, Microsoft Corporation, United State of America. Percentage difference was also calculated for comparison with the recommended annual limit by regulatory bodies.

RESULTS

Background radiation level in post guard area

Figure 2 represented the natural background radiation readings in post guard area of all schools. The overall pattern of the scattered line chart showed increasing pattern linearly in all of the schools. The increasing pattern of the trend line suggested positive accumulation of background radiation dose in the area throughout the period of data collection. During the first cycle, it was noted that the highest reading recorded was in SMK Air Putih (0.0154 mSv). Meanwhile, the lowest reading recorded in the first cycle was in SMK Tengku Panglima Perang Tengku Muhammad which is about 0.0064 mSv. However, towards the end of the fifth cycle, it was noted that SK Semambu recorded the highest reading of about 0.0232 mSv while SMK Tengku Panglima Perang Tengku Muhammad still holds the lowest reading which is about 0.0141 mSv during the end of data collection.

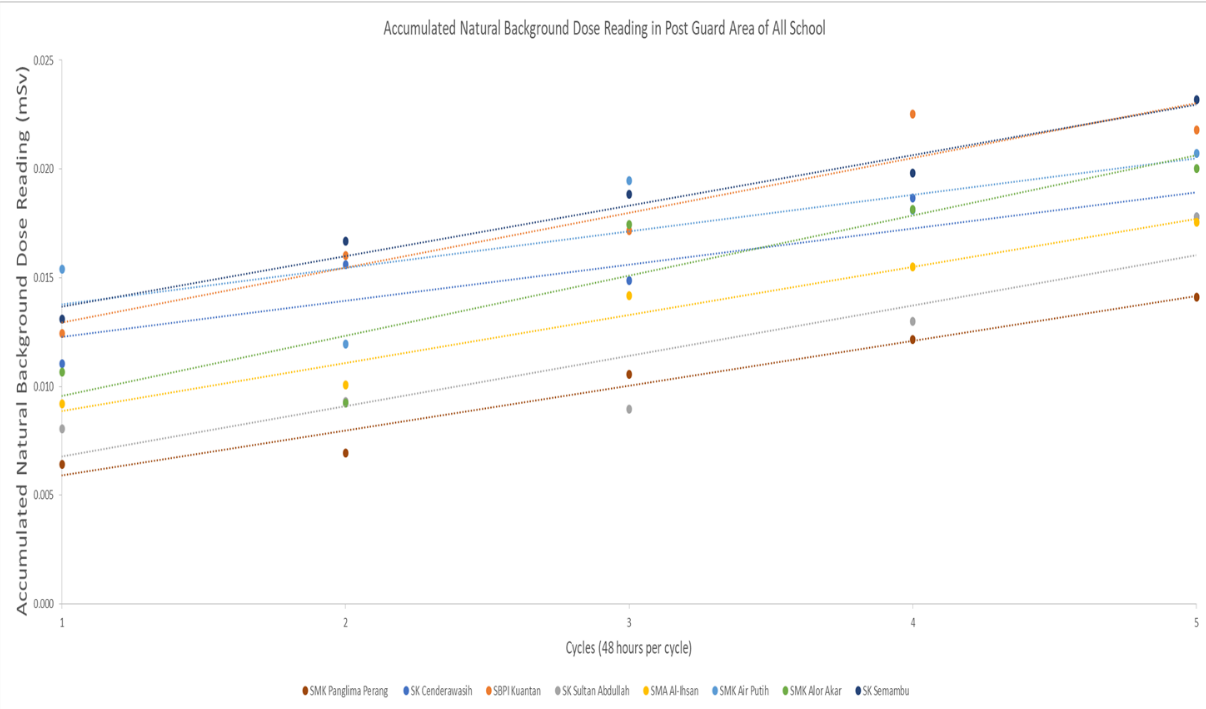

Figure 2: Accumulated natural background radiation dose recorded in post guard areas in different schools.

Background radiation level in assembly area

The readings of background radiation level recorded in assembly area in various schools are represented in Figure 3. It is found that the overall pattern of the scattered line chart showed an increasing pattern in all trend lines. Furthermore, the highest reading recorded during the first cycle of data collection was in SMK Air Putih which is about 0.0118 mSv. Meanwhile, the lowest reading recorded in the first cycle was noted in two schools which are SK Sultan Abdullah and SMK Tengku Panglima Perang Tengku Muhammad in which both of them recorded values at exactly 0.0071 mSv. However, towards the end of the fifth cycle, it was noted that SK Semambu recorded the highest reading of about 0.0242 mSv while SMK Tengku Panglima Perang Tengku Muhammad still holds the lowest reading which is about 0.0132 mSv during the end of data collection.

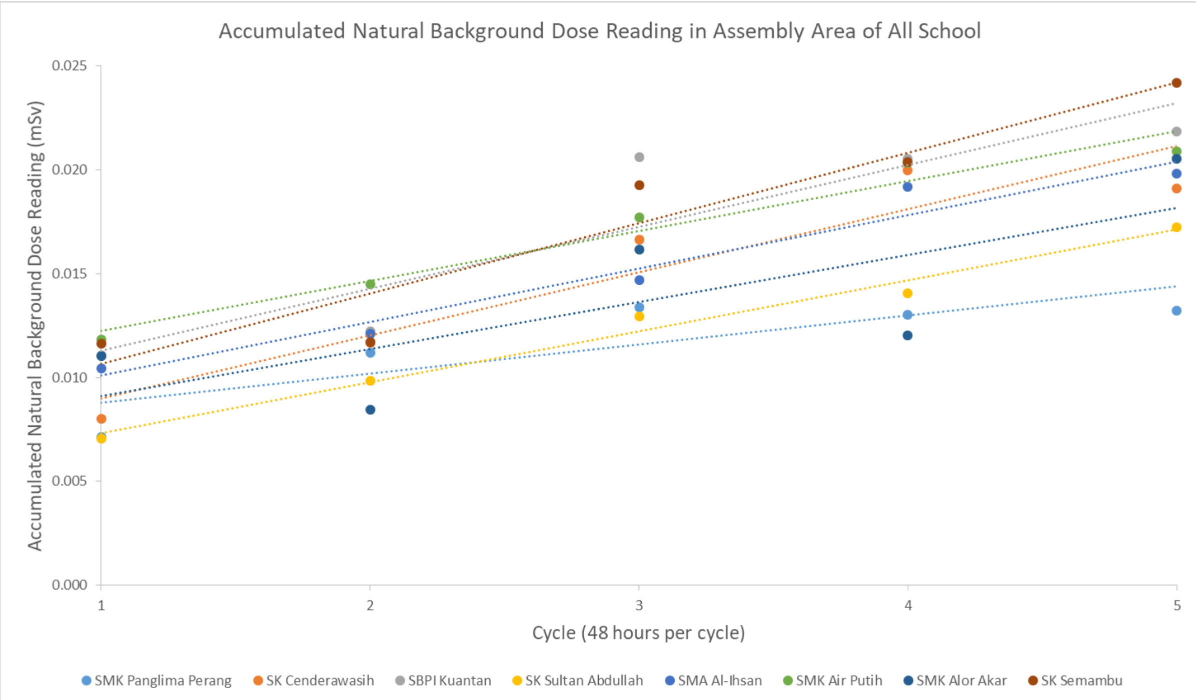

Figure 3: Accumulated natural background radiation dose recorded in assembly areas in different schools.

Comparison of background radiation level between post guard and assembly areas for different schools

In this study, the background radiation level for each locations were compared throughout the study period by placing the OSL dosimeters continuously of 15 days in the designated areas which are the post guard areas and assembly areas without any interruption or any attempt to remove it from the study place. Figure 4 demonstrated the comparison of natural background radiation dose between both post guard area and assembly area in all of the chosen schools determined in the study. For the post guard area, the highest value of natural background radiation dose recorded is found in SK Cenderawasih which is 0.0764 mSv while the lowest value is recorded in SMK Alor Akar which is at 0.0314 mSv. The highest reading of natural background radiation dose recorded in the assembly area is recorded in SK Semambu which is 0.0689 mSv while the lowest reading is found in SMK Tengku Panglima Perang Tengku Muhammad which is only 0.0293 mSv.

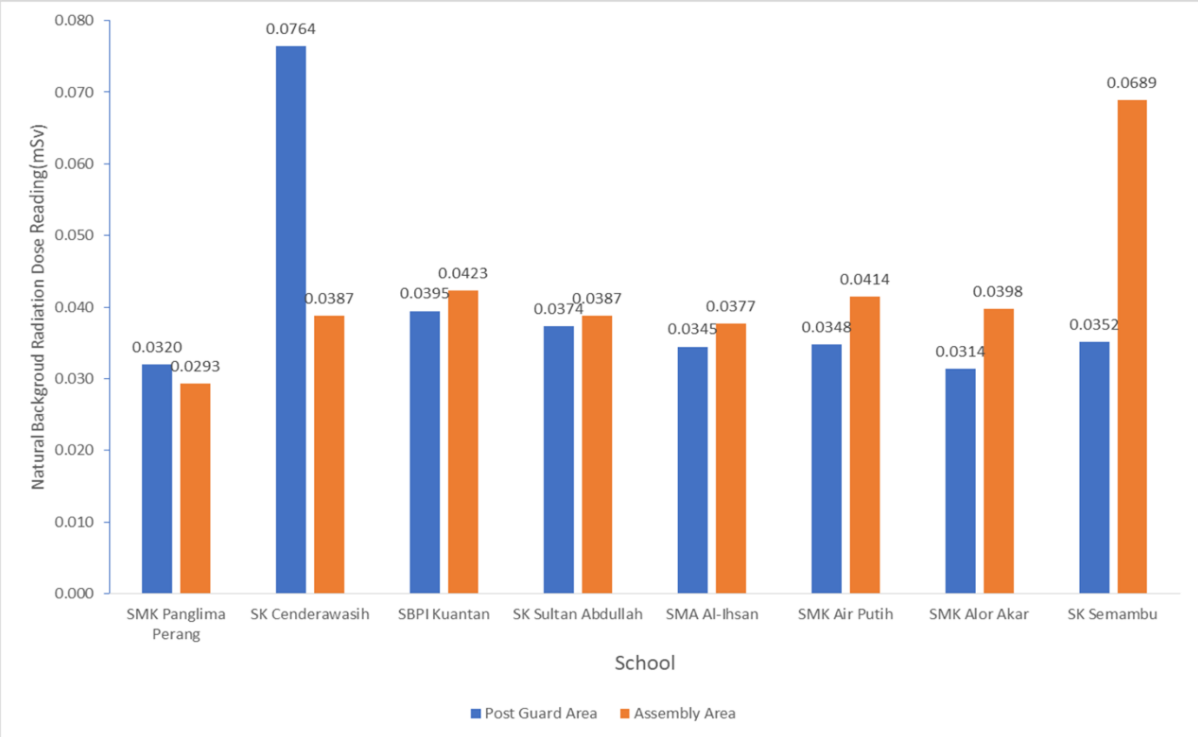

Figure 4: Comparison of background radiation level between post guard and assembly areas for different selected schools

Comparison of background radiation level with standard annual effective dose based on recommendation from different regulatory bodies

International Atomic Energy Agency (IAEA), Atomic Agency Licensing Board (AELB) and International Commission on Radiological Protection (ICRP) has recommended the standard annual effective dose of background radiation to public at 1.0 mSv per year. Calculations for the annual recorded dose for both post guard area and assembly area of all schools are done and tabulated in Table 2. Percentage difference was also calculated to compare the background radiation level obtained in this study with standard annual effective dose based on recommendation from different regulatory bodies. The highest percentage difference between the annual recorded doses with the standard annual effective dose in post guard area is in SMK Alor Akar which was 58.75%. Meanwhile, the highest percentage difference in assembly area is noted in SMK Tengku Panglima Perang Tengku Muhammad with value of 64.90% difference. On the other hand, the lowest percentage difference in post guard area calculated is found in SK Cenderawasih where a mere 28.20%. In assembly area, the smallest percentage difference calculated is evident in SK Semambu where a mere 18.02% percentage difference is obtained.

Table 2: Annual recorded readings in post guard areas and assembly areas of different schools and standard annual effective dose based on different recommendation agencies in percentage difference

Name of school	Placement location	Background radiation level (mSv)	Recommended annual effective dose limit (AELB, IAEA, ICRP)	Percentage Difference (%)
SMK Tengku Panglima Perang Tengku Muhammad	Post Guard	0.5557		57.12
	Assembly	0.5100		64.90
SK Cenderawasih	Post Guard	1.3283		28.20
	Assembly	0.6733		39.05
SBPI Kuantan	Post Guard	0.6858		37.28
	Assembly	0.7355		30.48
SK Sultan Abdullah	Post Guard	0.6494		42.51
	Assembly	0.6733	1 mSv/year	39.05
SMA Al-Ihsan	Post Guard	0.5989		50.17
	Assembly	0.6551		41.68
SMK Air Putih	Post Guard	0.6043		49.33
	Assembly	0.7197		32.60
SMK Alor Akar	Post Guard	0.5459		58.75
	Assembly	0.6193		47.02
SK Semambu	Post Guard	0.6113		48.25
	Assembly	1.1980		18.02

DISCUSSION

Possible influencing factors affecting background radiation

The natural background radiation level were contributed from several influence factors which are the geological, building materials and surrounding environmental factors. In short, these influencing factors contributed to the increment of accumulated dose recorded.

Influencing factor: Geographical

The elevation of the location from the sea level became an influencing factor in determining the amount of background radiation deposited in the area. The school that is located in higher altitude recorded higher background radiation level. Based on the topography map in Figure 5, SK Semambu is slightly elevated which is in 25m elevation above sea level. Thus, the background radiation level recorded in SK Semambu were the highest among other schools. This findings supported by Shahbazi-Gahrouei, Gholami, and Setayandeh in their study in 2013. The researchers found that background radiation level from the cosmic rays increases with the increasing altitude. Therefore, the one possible contributor of background radiation level is the exposure to the cosmic rays.

Coastal area is also a factor in influencing background radiation level. Coastal area is filled with sands and rocks that might contain the naturally occurring radioactive elements. Mahur, Kumar, Sengupta and Prasad (2009) explain that radionuclides that are naturally occurring such as 238U, 232Th and 40K are deposited within the beach sands. Geographically, SMA Al-Ihsan is located near to the coast line of Kuantan. Although the reading of background radiation level obtained were the third lowest in, the fact that the school is exposed to some kind of background radiation sources that is deposited in the sands still remains.

Hillside area influence the amount of background radiation recorded in this study. Achola, Patel, Mustapha, and Angeyo (2012) found that the hill area in Ruri, Kenya demonstrated higher value in background radiation reading. Furthermore, the researchers added that soil in this hill area was the main cause which affected the background radiation reading as the soil undergo decaying process which releases radioactive elements in the soil. Both SK Semambu and SBPI Kuantan are in located on a hill and near to hillside of Kuantan. SK Semambu recorded the highest accumulated dose followed by SBPI Kuantan with the second highest reading. Therefore, the result obtained in this study supported the findings of earlier study done by Achola et al. (2012).

Figure 5: Topographic map of selected schools in Kuantan, Pahang.

Influencing factor: building materials

Building materials used in constructing the school's buildings are an influencing factor to the background radiation reading. Generally, the building materials used were comprised of bricks, cements, gravels and gypsum. Shahbazi-Gahrouei et al. (2013) explained that these materials exhibits high amount of radionuclide elements such as 226Ra, 232Th and 40K. However, it is hard to determine the true composition of each building materials of the post guard building and the buildings near the assembly area of each school. Thus, it is considered safe to say that the radiation originated from the buildings are within the safe value. Also, further investigation of the true composition of building materials and radon contamination test should be included in future studies.

Influencing factor: surrounding environments

Surrounding environments that envelops the school influence the amount of background radiation level recorded. SK Semambu is located in an industrial area. Industrial area influenced the amount of background radiation reading due to the fact that the chemical released from the industrial buildings might contain radioactive substance. Nwankwo and Akoshile (2005) supported this claim as the researchers found that the background radiation level increases due to the fertilizer industry in Offa. Hence, the value of background radiation reading in SK Semambu became the highest compared to other schools that were not in an industrial area.

Comparison of background radiation level with recommended limit suggested by regulatory bodies

It is found that the majority of schools had background radiation level below than the recommended limit of 1 mSv per year suggested by regulatory bodies. However, there are two schools recorded background radiation level that surpassed the recommended limit. The post guard area of SK Cenderawasih and the assembly area of SK Semambu both exceeded the 1 mSv/year recommended limit. Nevertheless, the percentage difference for both of these places were comparatively small. It is recommended that continuous monitoring of background radiation level in these schools should be done to ensure the safety of its occupants.

CONCLUSIONS

The highest background radiation level recorded in post guard area is in SK Cenderawasih with 1.3283 mSv/year while the lowest background radiation level is in SMK Alor Akar with of 0.5459 mSv/year. In addition, the highest background radiation level recorded in the assembly area is in SK Semambu with 1.1980 mSv/year while the lowest background radiation level is in SMK Tengku Panglima Perang Tengku Muhammad with 0.5100 mSv/year. Overall, the background radiation level in majority of schools in Kuantan do not exceed the recommended limit of 1 mSv/year. However, continuous monitoring of background radiation level in SK Semambu and SK Cenderawasih should be done as the background radiation level recorded in both schools exceeded the recommended limit.

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