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DOSE MAPPING USING THERMOLUMINENSCENE DOSIMETER (TLD) AND GEOGRAPHICAL INFORMATION SYSTEM (GIS) TOOL FOR LONG TERM STORAGE FACILITY (LTSF), BUKIT KLEDANG, PERAK, MALAYSIA

Nur Khairunisa Zahidi[1], Faizal Azrin Abdul Razalim[1], Yii Mei Wo[2], Nazran Harun[2], Raymond Yapp Tze Loong[1], Noor Ezati Shuib[1], Ahmad Bazlie Abdul Kadir[1], Hassan Sham[1], Mohd Taufik Dollah[1], Rafizi Salehudin[2], Nurul Hani Farhana Mohamad Haider[1], Ahmad Hasnulhadi Che Kamaruddin[2], Azuhar Ripin[1], Abdul Rahmad Khalid[3], Muhammad Amirul Md Noor[3] and Nur Ain Abd Razak[3]

[1]Radiation Safety and Health Division,
Malaysian Nuclear Agency, Bangi, 43000 Kajang, Selangor, Malaysia
[2]Waste Technology and Environmental Division,
Malaysian Nuclear Agency, Bangi, 43000 Kajang, Selangor, Malaysia
[3]Menteri Besar Incorporated, Perbadanan Menteri Besar Perak,
30020, Ipoh Perak, Malaysia
Correspondence author: khairunisa@nm.gov.my

ABSTRACT

Dose mapping is one of the methods used to identify the dose distribution in any radiation facility. This study aims to visualise dose distribution at Long Term Storage Facility (LTSF), Bukit Kledang using thermoluminenscene dosimeter (TLD) by Geographical Information System (GIS). A total of 50 point were identified at LTSF for dose mapping using passive measurement, thermoluminescence dosimeter (TLD). TLD chips undergo anneal process before using, installed at dedicated location, exposed for one month and analysed using TLD reader at Secondary Standard Dosimetry Laboratory (SSDL), Malaysian Nuclear Agency. The obtained results showed, the average cumulative dose per month and annual dose ranged from 0.04 – 0.16 and 0.08 – 0.38 respectively. The results showed that there were no significant increase as compared to previous continuing environmental programme (EMP) in 2017 and the annual dose is also below the stipulated limit for public by Atomic Energy Licensing Board (AELB).

Keywords: Dose mapping, passive measurement, radiation, *Long Term Storage Facility (LTSF), thermoluminescence dosimeter (TLD), Geographical Information System (GIS)*

INTRODUCTION

Nuclear radiation can be found anywhere and human has always been exposed internally (inhalation, ingestion, skin absorption, open wound) and externally (irradiation from gamma, x-rays) to radiation from natural background and man-made. Environmental surveillance is an important component of the verification system to verify that the controls on the releases of radioactive substances to the environment are functioning under normal working conditions (IAEA, 1982). The environmental surveillance can be done by numerous methodologies and one of the methodologies discussed in this paper is by creating a dose mapping using passive measurement, TLD and GIS tools at LTSF, Bukit Kledang Perak. The repository facility is upgraded from LTSF upon completion of decontamination and decommissioning (D&D) process (AELB, 2016). The previous site license holder of the repository facility is Asian Rare Earth (ARE) Sdn Bhd. ARE is a joint venture between Malaysians and Japanese, which was incorporated in Ipoh on November 23,1979 and began operating in May

1982, its function being to extract rare earths from monazite sand, a residue of tin mining (Wagner et.al., 1989). Monozite sand contains rare earth and the radioactive element thorium. Prior to be collected for further processing, piles of monazite are found throughout the environments of Ipoh in amang factories. Amang is the residue of mixed minerals that remains in sand after the extraction of tin. After extraction rare earth completed, the concentration is twice original content, 12%. The final residue is treated as radioactive waste and stored in controlled area known as LTSF. The surrounding community believes that the study area is hazardous and provides additional external radiation. The main objective of this paper is to establish the dose mapping for LTSF, Bukit Kledang for better understanding of dose distribution in mentioned area.

MATERIALS AND METHODS

Sampling area

This study has been carried out at the LTSF, Bukit Kledang, Perak which is located at Mukim Blanja and ~15km driving from Ipoh town. The repository in Mukim Belanja are from ARE plant and LTSF decommissioning projects. After the completion of three-year surveillance period by ARE contractor, the responsibility to manage the repository site has been transferred to the Perak State Government (PSG) through MB Inc. Menteri Besar Incorporated (MB Inc.) Perak State.

Sampling and sample preparation

A total 50 points were identified at on-site LTSF and 3 points off-site LTSF and act as a control for this study. Dosimeter box were placed at 1-metre-high at specified location. Each thermoluminescence dosimeter (TLD) undergo annealing process using anneal oven and were placed in dosimeter box for one (1) month. The TLD chips were analysed using TLD reader at Secondary Standard Dosimetry Laboratory (SSDL), Malaysian Nuclear Agency. The sampling was carried out four (4) times in a year. The sampling locations are shown as in Figure 1.

Figure 1: Sampling location at LTSF Bukit Kledang, Perak.

Visualize dose mapping

The average cumulative dose for each point were visualised by colour using GIS tools. The Inverse Distance Weighted (IDW) technique is used to interpolate dose at LTSF, Bukit Kledang Perak. IDW estimates unknown values with specifying search distance, closet point, power setting and barriers (GISGeography, 2022). The dose distribution is categorized into six (6) group with different colour. The visualize dose mapping using IDW was shown as in Figure 2.

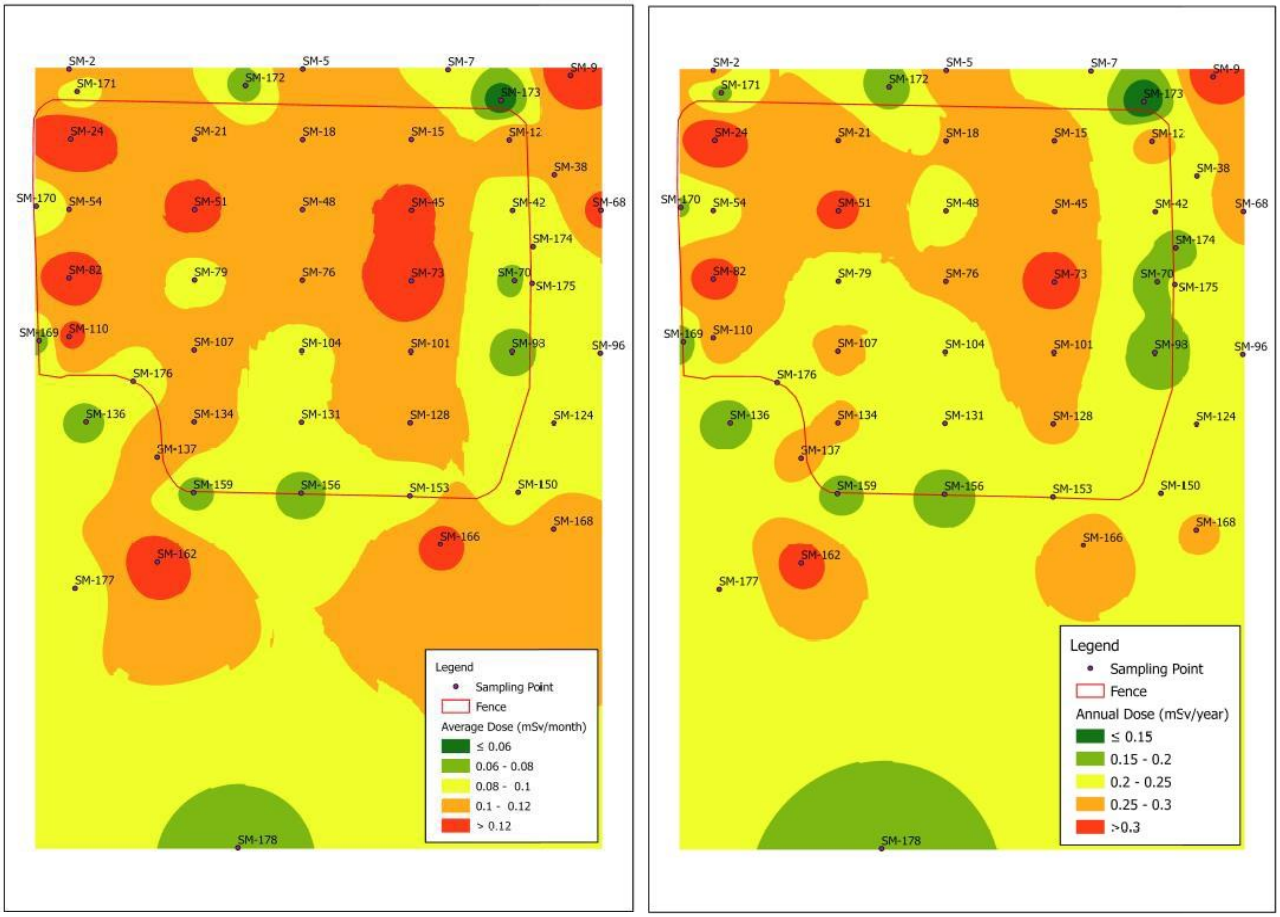

Figure 2: Visualise dose mapping (mSv/month and mSv/year) at LTSF Bukit Kledang, Perak using GIS tools.

Annual Dose Calculation

The annual dose is calculated using the following equation:

Annual effective dose (mSv) = $D \times 12 \times 0.2$ …… Eq (1)

where,
D: Average cumulative dose in mSv/month,
12: month in a year
0.2: external occupancy factor

RESULTS AND DISCUSSION

Table 1.0 shows the average results of measurement of 50 sampling points at sampling area. The minimum and maximum average dose per month and per year is 0.04 and 0.16, respectively. The data shown is compared with the previous monitoring using the same passive measurement. In the previous environmental program of continuing EMP for LTSF Bukit Kledang Perak in 2017, the average dose per month ranged between 0.18 – 0.82 at on-site and off-site monitoring station (MB Inc. Perbadanan Menteri Besar Perak, 2019) thus the data shows no remarkable increase of average dose per month at LTSF Bukit Kledang, Perak. Based on Figure 3.0, the maximum annual dose and the average annual dose is 0.38 and 0.24 ± 0.06 mSv, respectively. The value shown is below the dose limit for public member, 1 mSv/year as stipulated by AELB (AELB, 2010). There is no similar research related to

this study in other country. However, there is one study in German regarding the radiation dose level at fence with additional cask in the repository facility since 1997 until 2011 and the maximum annual dose found to be 0.22 mSv (Oelschlager. L. et al., 2013). The results from this study are similar as in Germany repository facility study where the annual dose at fence of LTSF Bukit Kledang is ranged between 0.16 t0 0.22 mSv annually.

Table 1: The results of average dose monitoring at LTSF, Bukit Kledang, Perak.

Sampling Point	GPS Coordinates		Average Dose (mSv/month)	Annual Dose (mSv/year)
	Latitude (DMS)	Longitude (DMS)		
SM-2	4°33'14.7"	101°00'46.8"	0.12 ± 0.03	0.28
SM-5	4°33'14.7"	101°00'50.4"	0.12 ± 0.04	0.29
SM-7	4°33'14.7"	101°00'54.0"	0.09 ± 0.06	0.22
SM-9	4°33'14.5"	101°00'54.0"	0.15 ± 0.06	0.36
SM-12	4°33'13.4"	101°00'54.0"	0.12 ± 0.02	0.28
SM-15	4°33'13.4"	101°00'54.0"	0.12 ± 0.04	0.28
SM-18	4°33'13.4"	101°00'50.4"	0.11 ± 0.07	0.25
SM-21	4°33'13.4"	101°00'46.8"	0.12 ± 0.04	0.28
SM-24	4°33'13.4"	101°00'46.8"	**0.16 ± 0.06***	**0.38***
SM-38	4°33’12.7”	101°00’54.0”	0.10 ± 0.04	0.25
SM-42	4°33’12.1”	101°00’54.0”	0.09 ± 0.08	0.21
SM-45	4°33’12.1”	101°00’54.0”	0.13 ± 0.04	0.30
SM-48	4°33’12.1”	101°00’50.4”	0.10 ± 0.07	0.23
SM-51	4°33’12.1”	101°00’46.8”	0.13 ± 0.07	0.32
SM-54	4°33’12.1”	101°00’46.8”	0.13 ± 0.04	0.23
SM-68	4°33’12.1”	101°00’54.0	0.13± 0.04	0.30
SM-70	4°33’10.8”	101°00’54.0”	0.07 ± 0.08	0.17
SM-73	4°33’10.8”	101°00’54.0”	0.15 ± 0.03	0.35
SM-76	4°33’10.8”	101°00’50.4”	0.11 ± 0.06	0.25
SM-79	4°33’10.8”	101°00’46.8”	0.09 ± 0.05	0.21
SM-82	4°33’10.8”	101°00’46.8”	0.14 ± 0.04	0.34
SM-96	4°33’09.4”	101°00’54.0”	0.10 ± 0.05	0.23
SM-98	4°33’09.5”	101°00’54.0”	0.07 ± 0.05	0.17
SM-101	4°33’09.5”	101°00’54.0”	0.12 ± 0.02	0.28
SM-104	4°33’09.5”	101°00’50.4”	0.09 ± 0.06	0.22
SM-107	4°33’09.5”	101°00’46.8”	0.11 ± 0.04	0.26
SM-110	4°33’09.7”	101°00’46.8”	0.13 ± 0.04	0.30
SM-124	4°33’08.1”	101°00’54.0”	0.09 ± 0.04	0.20
SM-128	4°33’08.1”	101°00’54.0”	0.11 ± 0.02	0.26
SM-131	4°33’08.1”	101°00’50.4”	0.10 ± 0.01	0.25
SM-134	4°33’08.1”	101°00’46.8”	0.11 ± 0.03	0.26
SM-136	4°33’08.1”	101°00’46.8”	0.07 ± 0.05	0.17
SM-137	4°33’07.5”	101°00’46.8”	0.12 ± 0.06	0.28
SM-150	4°33’06.9”	101°00’54.0”	0.09 ± 0.03	0.20
SM-153	4°33’06.8”	101°00’54.0”	0.09 ± 0.04	0.20
SM-156	4°33’06.8”	101°00’50.4”	0.07 ± 0.05	0.17
SM-159	4°33’06.8”	101°00’46.8”	0.07 ± 0.05	0.17
SM-162	4°33’05.5”	101°00’46.8”	0.14 ± 0.03	0.33
SM-166	4°33’05.9”	101°00’54.0”	0.13 ± 0.04	0.30
SM-168	4°33’06.2”	101°00’54.0”	0.11 ± 0.04	0.26

SM-169	4°33’09.6”	101°00’46.8”	0.07 ± 0.05	0.16
SM-170	4°33’12.1”	101°00’46.8”	0.08 ± 0.06	0.19
SM-171	4°33’14.2”	101°00’46.8”	0.08 ± 0.04	0.18
SM-172	4°33’14.4”	101°00’50.4”	0.07 ± 0.05	0.16
SM-173	4°33’14.1”	101°00’54.0”	**0.04 ± 0.03***	**0.08***
SM-174	4°33'11.4"	101°00'54.0"	0.08 ± 0.02	0.18
SM-175	4°33'10.7"	101°00'54.0"	0.09 ± 0.05	0.21
SM-176	4°33'08.9"	101°00'46.8"	0.09 ± 0.07	0.22
SM-177	4°33'05.0"	101°00'46.8"	0.09 ± 0.04	0.20
SM-178	4°33'00.3"	101°00'50.4"	0.07 ± 0.05	0.16

***** The bold characters represent the minimum and maximum values.

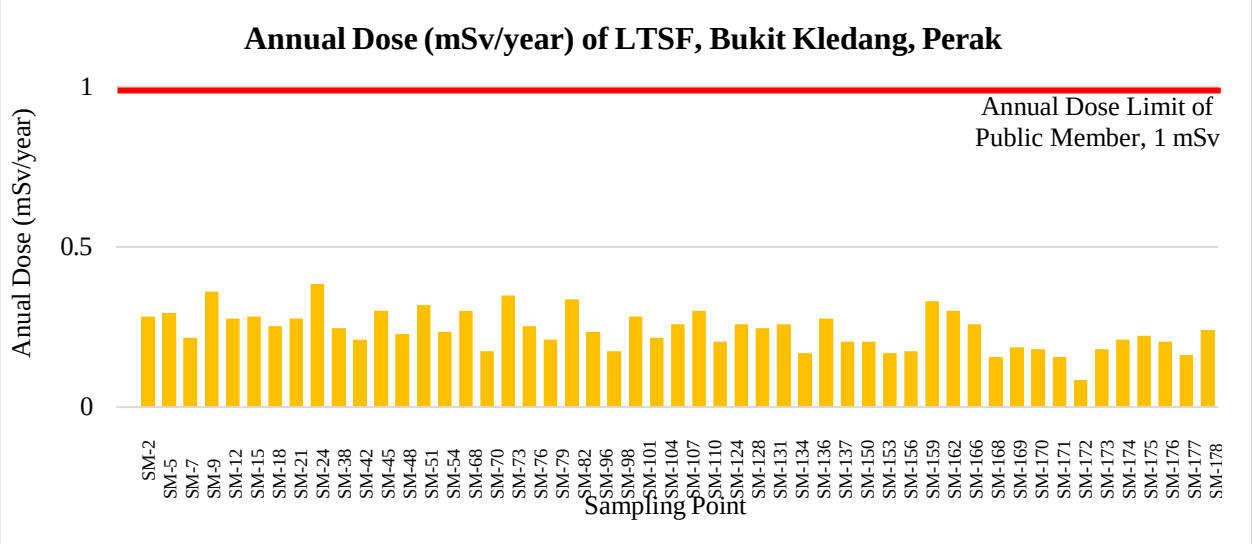

Figure 3: Annual dose (mSv/year) at LTSF Bukit Kledang, Perak and dose limit for public member.

CONCLUSIONS

The measurement of 50 points at on-site LTSF using TLD were analysed by monthly basis in each sampling. The maximum annual dose and the average annual dose is 0.38 and 0.24 ± 0.06 mSv, respectively. The value shown is far compared to the dose limit for public member, 1 mSv/year as stipulated by AELB (AELB, 2010).

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