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Monitoring of radiation dose rates around a clinical nuclear medicine site

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HIGHLIGHTS

- Observed unexpected high dose rates in the non restricted waiting area.
- Provides useful Radiation Dose Rates information in nuclear medicine radioactive waste water pipeline system.
- Provide TLD setup method in environmental radiation dose evaluate.

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ABSTRACT

The monitoring of radiation dose around the nuclear medicine site is an important study issue. In this study, TLD-100H radiation dosimeters were used to measure the ambient radiation dose rates around a clinical nuclear medicine site in order to investigate the latent hot zones of radiation exposure. Results of this study showed that the radiation doses measured from all piping and storage systems were comparable to the background dose. A relatively high dose was observed at the single bend point of waste water piping of the PET/CT. Another important finding was the unexpected high dose rates observed at the non-restricted waiting area (NRWA) of SPECT.

To conclude, this study provides useful information for further determination of an appropriate dose reduction strategy to achieve the ALARA principle in a clinical nuclear medicine site.

1. Introduction

Over the last decades, there has been a dramatic increase in the uses of man-made isotopes in nuclear medicine diagnosis, in vitro assays, therapy, as well as nuclide synthesis at clinical nuclear medical sites. This has been accountable for environmental pollution in the form of increased radioactive dose exposure to the general public, based on the fundamental properties of each different isotope (Mackenzie, 2000; Little, 2003). Several studies have reported the related spatial radiation dose rates on patient and medical personnel effective dose in nuclear medicine examination sites (Mettler Jr et al., 2008; Leide-Svegborn, 2010, 2012). The aforementioned suggests the need for further research on appropriate executable dose reduction strategy (U.S. Nuclear Regulatory Commission, 1997; Roberts et al., 2005).

Few studies have focused on radioactive wastewater discharge and storage in clinical nuclear medicine and its environmental impact (Sundell-Bergman et al., 2008; Barquero et al., 2008). In this study, a survey of ambient radiation dose rates was carried out by using LiF: Mg, Cu, P thermoluminescent dosimeters (TLD-100H) due to their higher sensitivity to low dose rates. This was utilized in various detection sites to investigate the latent hot zones in a clinical nuclear medicine site, as well as radiation dose rates in radioactive wastewater discharge and storage systems.

2. Materials and methods

2.1. Description of investigation site

The site selected for this investigation is the nuclear medicine department in Chung Shan Medical University Hospital (CSMUH), which is one of the 19 certified medical centers in Taiwan. The department is located in the basement of the main building. It executes diagnostic studies with a positron emission tomography/computed tomography scanner (PET/CT, PHILIPS GEMINI GXL), a single photon emission computed tomography/computed tomography scanner (SPECT/CT, SIEMENS Symbia T2), gamma camera

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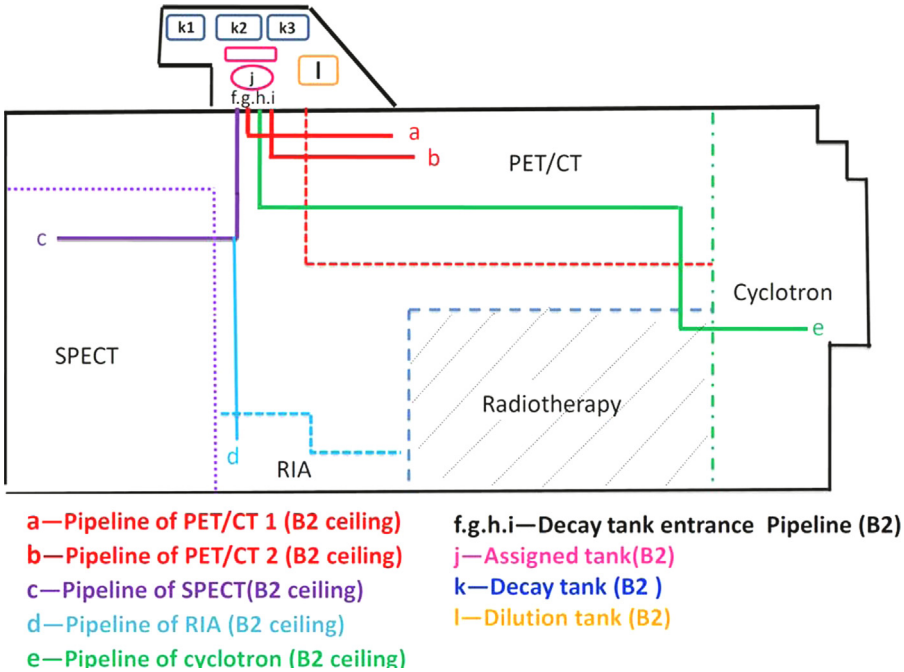

Fig. 1. Architecture of investigate region A and B in CSMUH.

Table 1
Number of monitor point, number of TLDs and investigation site in each region.

Investigation area A		Monitor number	TLD′s number	Investigation area B		Monitor number	TLD′s number
Mark	Site			Mark	Site		
A	PET-CT: information desk	2	6	a	PETCT pipeline 1	5	15
B	Control room	2	6	b	PETCT pipeline 2	5	15
C	Restricted waiting area	10	30	c	SPECT pipeline	10	30
D	Post injection rest area	4	12	d	RIA pipeline	14	42
E	Injection preparation area	2	6	e	Cyclotron pipeline	21	63
F	SPECT: information desk	2	6	f-i	Entry pipeline (1–4)	4	12
G	Control room	2	6	j	Assigned tank	9	27
H	Non restricted waiting area	20	60	k	Decay tank (1–3)	27	81
I	Restricted waiting area	6	18	l	Emergency dilution tank	11	33
J	Injection preparation area	2	6	m	Upper connection pipeline	5	15
K	RIA Working desk	4	12	n	Lower connection pipeline	5	15
L	Aisles around	10	30	o	Background B	1	3
M	Background A	1	3				
	Total	67	201			117	351

(SIEMENS E.CAM), radioimmunoassay (RIA), as well as a medical cyclotron (CTI RDS-111). The whole basement region was selected as investigation area A, but the neighboring radiation therapy department was excluded. The neutron and photon dose rate in the cyclotron of investigation area A has been previously reported (Lee and Chen, 2008). In the second basement of the building, the radioactive wastewater discharge pipelines were connected with the nuclear medicine department and the end of the pipelines were connected to the decay and dilution tank. These regions were selected as investigation area B. The architecture of both investigation areas A and B are shown in Fig. 1.

The pipelines were hung on the ceiling at 3.4 m height above the ground, made of stainless steel 2 mm in thickness (ASTM316) with different diameters and lengths. There were five different lengths and two different diameters. A minority of the pipelines have a 90-degree horizontal or vertical bend point. Those pipelines were placed under an appropriate inclination for flow without specific radiation protection shielding.

2.2. Radiation dose rates measuring in investigation points

2.2.1. Thermoluminescent dosimeters

Lithium fluoride TLD is the most common equipment for clinical radiodosimetry measurement. Whenever a higher sensitivity to low-dose rate is required, LiF: Mg, Cu, P dosimeter (TLD-100H) is frequently employed (Leide-Svegborn, 2010; Al-Haj et al., 2011). A total of 552 high sensitivity thermoluminescent dosimeters Harshaw TLD-100H (Thermo Electron Co, Oakwood Village, OH), with a volume of $3.0 \times 3.0 \times 0.89\ mm^3$,were used to monitor the radiation dose. Each chip converted response (nC) to radiation dose exposure by its inbuilt sensitivity correction factor after readout.

2.2.2. Monitor points establishment

Three chips were packed in a plastic bag and placed in each monitor point. The radiation dose was monitored for a period of one month. In investigation area A, each TLD bag was attached