Original Article

Institutional Experience of Routine Radiation Surveillance of Delay and Decay Tanks Facility in a Department Having High-dose Iodine Therapy Unit

Amandeep Kaur, Yasmeen Atwal Sonik, Bhavay Sonik

Department of Nuclear Medicine, Guru Gobind Singh Medical College and Hospital, Faridkot, Punjab, India

Abstract

Background: Radioactive solid and liquid waste generated by patients after high-dose iodine therapy may lead to significant radiation exposure if not properly handled. **Aims and Objectives:** This study was conducted to monitor the radiation exposure along the sewerage drainage system of the high-dose iodine therapy ward and to rule out leakage if any, that might pose a potential radiation hazard to the general public (sewerage workers) and radiation health professional. **Materials and Methods:** The sewerage drainage system from isolation wards has multiple gate valves to regulate sewerage flow from the high-dose iodine therapy ward into delay and decay tanks (DDT) built, especially for the purpose. Radiation surveillance was done using a Geiger-Muller counter-based survey meter at 11 different locations on a weekly basis for 12 weeks. **Results:** A total of 26 patients underwent high-dose iodine ablation therapy during the study period in our department, with the highest recorded radiation exposure rate in the sewerage draining system in the 9th week of patient admission. This was at the common gate valve junction (location B) that directed sewerage waste from all four isolation rooms into the common pipeline leading to DDT. Minimal radiation exposure was recorded within Atomic Energy Regulatory Board -prescribed limits with no evidence of leakage. **Conclusion:** A routine radiation survey is an important component of overall radiation safety in the nuclear medicine department, including sewerage delay tank facilities, which helps keep the radiation exposure to acceptable levels by identifying timely leakage.

Keywords: *High-dose iodine therapy, radiation exposure rate, radiation health professional, radiation surveillance*

Introduction

Nuclear medicine uses radioactive iodine or 131-I for diagnostic and therapeutic purposes in thyrotoxicosis and thyroid carcinoma. 131-I has a physical half-life of 8.04 days and a biological half-life of 80 days in the thyroid gland for adults, giving an effective half-life of 7.3 days.[1] This means that within 3 days of administration of 131-I, nearly 70% of it is excreted in the patient's urine.[2,3]

Atomic Energy Regulatory Board (AERB) mandates that thyroid cancer patients undergoing high-dose I-131 therapy (HDIT) be admitted in isolation wards/rooms having separate sewerage drainage systems that drain into specially designed delay and decay tanks (DDT).[4-12] The Nuclear Medicine Department at GGSMCH Faridkot has four isolation rooms for HDIT patients which have separate sewerage draining systems leading to two concrete DDTs. These isolation rooms are located on the first floor of the department with DDT being located at the backside of the department in an area with minimal public movement to minimize radiation exposure to health workers as well as members of the general public in case of any leakage.

The two delay tanks located below ground level have a capacity of 12,000 L each 2 m [L] ×2 m [W] ×3 m [D], and are concrete lined and covered with concrete slabs. The flow in and out of these tanks is managed by manually operated valves, through single inlet and outlet pipes. For monitoring the effluent levels and in delay tanks, floating switches are installed at a depth of 50 cm from the top, which are connected to an alarm located at the nursing station inside the department. The alarm goes off when the tank reaches 85% of its capacity, giving a flush volume of 10,200 L for each tank. The valves are then

Address for correspondence:
Dr. Bhavay Sonik,
Department of Nuclear Medicine, Guru Gobind Singh Medical College and Hospital. Faridkot (151203), Punjab, India.
E-mail: dr.bhavaysonik@gmail.com

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manually operated to change the flow of effluent into the second delay tank. The effluent thus collected in the first delay tank is then allowed to undergo delay and decay for approximately 3 months, i.e., 10 half-lives of I-131.[3-6]

After completion of 3 months, sampling is done from the first delay tank by collecting approximately 1 mL of sewerage liquid from an inspection point (gate valve located approximately 2 m away from the delay tanks [Figure 1]. This 1 mL of the sample is mixed with 1 mL of tap water, which is then measured in the well-counting system of Capintec (Captus 3000). As per AERB guidelines, when 131-I activity levels fall below 22.2MBq/m^3, sewerage waste can be released from the delay tank into the general sewerage system of the hospital.[4,5,13]

The documentation for filling, closing, emptying, and measuring of radioactivity of released effluents is done by the Radiation Safety Officer (RSO) of the Nuclear Medicine Department.[11]

Many studies have been conducted in the past to assess the radiation exposure rate (RER) from the effluent of the DDT facility before releasing it into the public sewerage system.[4-10] However, to the best of our knowledge, no recent study has been done to measure the RER around the draining system of a DDT facility.

Aims and objectives

The current study was undertaken in the form of a radiation survey conducted using GM-based survey meter around the sewerage drainage system of the HDIT ward leading to DDT. A total of 11 different locations were surveyed and readings were recorded to check for any leakage that might pose a potential radiation hazard to sewage workers and radiation health professionals.

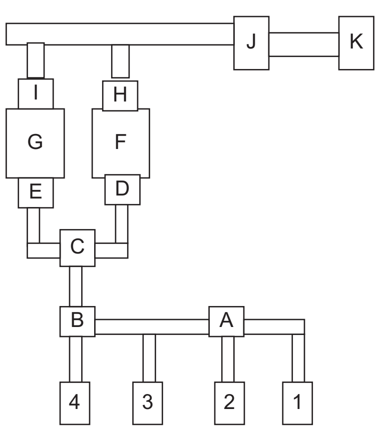
Materials and Methods

The thyroid carcinoma patients scheduled to undergo HDIT are admitted on Tuesday or Wednesday every week in the isolation ward of our department. They stay for an average of about 1–3 days depending upon the disease burden and dose of I-131 administered. They are discharged only after RER at a 1 m distance is <5 mR/h as per AERB guidelines.[13]

Before starting the study, DDT 2 was full and its inlet valve closed; whereas DDT 1 was empty and its inlet valve open. A radiation survey meter (RAM GENE-1, ROTEM) measured RER in μSv/h on Wednesday or Thursday when HDIT patients were using the toilets of isolation rooms and there was a flux of sewerage through the drainage system as chances of leakage, if any, were higher during that time. As per standard practice, we performed a swipe sample test around the delay tank facility while opening or closing its inlet or outlet valves. The swipe sample was performed by departmental RSO and no leakage was noted around the valves of both DDTs.

The RER was measured continuously for 12 weeks using Geiger-Muller (RAM GENE-1, ROTEM)-based detectors at 11 different locations around the DDT facility [Figure 1 and Table 1]. The distance between two adjacent locations varied between 1 and 5 m.

The survey meters were wrapped in a plastic sheath to prevent any external contamination while in use. The surveyor wore shoe covers and gloves in addition to the lab coat and TLD worn regularly. The survey meter was placed on an even surface at each location for 30 s to record the reading.



Locations	Demarcations
1,2,3 and 4	Four Isolations rooms
A	Manhole chamber of 1st and 2nd Isolation rooms
B	Manhole chamber of 3rd, 4th isolation rooms
C	Common gate valve
D	Inlet valve of Delay tank 1
E	Inlet valve of Delay tank 2
F	Delay tank 1
G	Delay tank 2
H	Outlet valve of delay tank 1
I	Outlet valve of delay tank 2
J	Inspection point for collecting sample operated with manual valve system
K	Manhole of Hospital sewerage pipeline

Figure 1: Layout plan of the delay and decay tanks facility present in High Dose Iodine Therapy Facility in Nuclear Medicine Department of GGSMC and H

Table 1: Number of patients and total activity administered (131-I) to the patients in high-dose I-131 therapy in 12 consecutive weeks

	Number of weeks											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Activity administrated each week (GBq)	14.8	7.4	0	35.15	0	25.9	0	35.15	27.75	0	0	7.4
Number of patients administrated	3	1	0	5	0	5	0	6	5	0	0	1

Results and Discussion

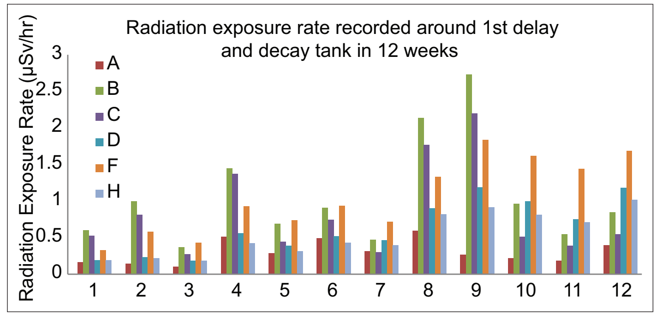
A total of 26 patients were administered HDIT during the 12 weeks of the study period. Among the 26 patients, 10 were male (age range: 23–67 years) and 16 were female (age range: 19–85 years). The administered dose of radioiodine was in the range of 2.96–9.07 GBq (mean: 6.01 GBq) [Table 1].

The RER during the study period of 12 weeks gradually increased at the surface of DDT 1 (location F). This was due to the fact that DDT 1 was the tank receiving an active flow of sewerage from the isolation wards during the study period. This led to a gradual build-up of radioactivity levels in the tank as the effluent collected led to an increase in the RER over time [Graph 1].

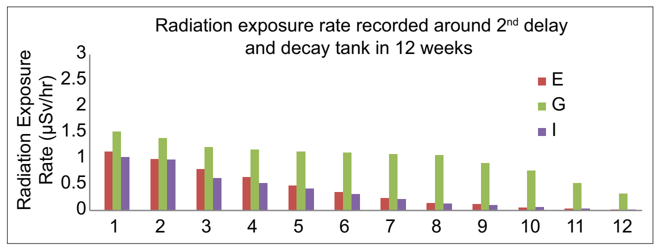
On the other hand, RER gradually decreased at the surface of DDT 2 (location G). This can be attributed to the fact that DDT 2 was already full and was not in active use. The inlet and outlet gate valves were closed for the stored radioactive effluent to undergo delay and decay over 3 months, which showed a gradual reduction in surface RER [Graph 2].

Since no patients were admitted to isolation rooms during the 3rd, 5th, 7th, 10th, and 11th weeks of our study period, a reduction in RER readings of delay and decay tank 1 was observed. A similar observation was also reported by Fahmi *et al*. Their study showed that the exposure rate and total count of the delay and decay tank sample increased when the radioiodine ward was fully occupied with patients and decreased when the ward was vacant. Moreover, the highest exposure rate recorded in their study was when the isolation ward was occupied for 2 consecutive weeks at 177.00 μR/h.[6]

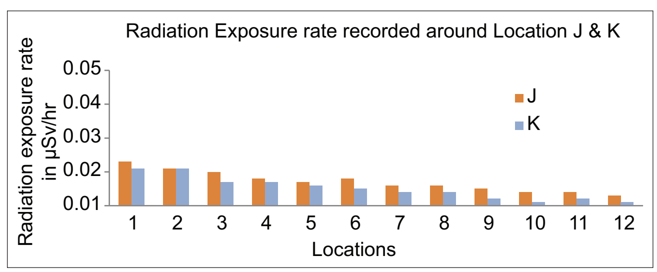
In our study, the highest/maximum RER of 2.139 μSv/h was recorded in the 9th week at location B, which drains sewerage waste from all four isolation rooms before leading to the common gate valve opening into the delay and decay tank [Graph 1]. This can be attributed to the administration of a higher amount of radioactivity to patients during those weeks and also from increased cumulative background activity in the pipelines from previous weeks. Furthermore, the RER in the 9th week at all other locations was found to be relatively higher than in other weeks. However, there are no definitive permissible limits for delay and decay tank facility, we considered an effective dose to a member of the public (1 mSv/year or 0.1141 μSv/h) as a permissible/allowable limit in our study. We would like to mention here



Graph 1: A bar graph depicting the rate of radiation exposure at 6 different locations around the delay and decay tank 1 facility in 12 consecutive weeks



Graph 2: A bar graph depicting the rate of radiation exposure at 3 different locations around the delay and decay tank 2 facility in 12 consecutive weeks



Graph 3: A bar graph depicting the rate of radiation exposure at Location Jammu and Kashmir around the delay and decay tank facility in 12 consecutive weeks

that, the area around the delay and decay tank facility is cordoned off by fencing and radiation warning symbols are prominently displayed. Nobody is allowed to enter the facility without the permission of the departmental RSO.

On the other hand, at locations Jammu and Kashmir, the RER ranges during our study period from 0.23 to 0.13 μSv/h with outlet valves of both delay tanks being closed and there is no active flow of sewerage through these points [Graph 3]. The Jammu location is more than a 2-m distance away from DDT 1, with the location Kashmir being still further away. The recorded reading of

RER at location Jammu; could be attributed to the fact that DDT 1 was emptied before the start of the study. As we are using GM-based survey meter for the survey and being a highly sensitive instrument, it detects a minimal amount of radioactivity. Moreover, no increase in RER at location Jammu was noted during the study, thus the above recorded RER may be attributed to background reading levels. It also reenforced the fact that no leakage was happening from DDT 2 (which was full) at the start of the study. Kheruka SC (2020) mentioned in their study that the highest exposure rates were recorded near the delay and decay tank and that rapidly decreases when moving to the surrounding area. It may be explained by the inverse square law, where an increase in distance from the radioactive source results in a decrease in exposure to the radioactive source.[6]

As per guidelines, sewerage waste should be removed from the DDT when 131-I activity levels fall below 22.2 MBq/m^3 to reduce public concern about released radioactive waste from hospitals.[4,5,13] Before the start of the study, DDT 2 was full and its inlet valve closed; whereas DDT 1 was empty and its inlet valve open. Thus, 3.2MBq/m^3 reading was noted at the time of discharge from our delay tank 1 into general hospital sewerage in our hospital setting before the start of the study.[13] No release of waste from both the DDTs was done during the study period.

Conclusion

To summarize, we would like to emphasize the need for routine radiation surveys of potential leakage points in the HDIT unit. This is important from the point of overall radiation safety and helps to keep the radiation exposure to acceptable levels by identifying timely leakage.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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