DECONTAMINATION OF ^{125}I IN MEDICAL LABORATORY

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ABSTRACT

A radiological laboratory for diagnoses was contaminated by ^{125}I. A large-scale survey of gamma-radiation has been made in different locations of the floors and walls of the lab to determine the contaminated area and its activity. The activity level before decontamination for the wall and floor was 1400 and 2000 Bq/cm^2 respectively. Decontamination was carried out by using ethyl alcohol, potassium permanganate, ethylene diamine tetracetic acid and tissue papers. Decontamination factor has been calculated and it was 175 and 200 for the wall and floor respectively. D&D computer code has been used to calculate Total Effective Dose Equivalent (TEDE). TEDE from the wall and floor before decontamination were 3.05 and 4.35 (mSv/yr) while after decontamination were 18 and 23 μSv/yr respectively. These results are lower than the Egyptian and the international regulations (10 mSv/y for the public) according to International Atomic Energy agency, IAEA, Safety Series, SS, no. 115 (1994).

INTRODUCTION

There are many thousands of small nuclear facilities including radiochemical laboratories, hospital installations, hot cells, waste treatment and decontamination facilities, which will eventually need to be decommissioned. Before starting dismantling activities, the characteristics and distribution of the radioactive and toxic materials (e.g. asbestos) and radiation fields in the facility must be defined(1). Removal of contaminants from surfaces before decommissioning process is generally based on cleaning techniques which have been well established for several decades (2). Decontamination involves the removal of bulk contaminants, and decommissioning involves the removal and cleanup of contaminated equipment. Almost all the procedures and reagents used in decontaminating equipment and facilities in the nuclear industry were first developed and used for cleaning conventional non-nuclear plants. Decontamination is understood as a process that should meet several criteria, such as: adequate decontamination factors; acceptable corrosion rates; easy availability of the equipment; simple operation and control; acceptable time requirements; satisfactory safety aspects (both radiological and non-radiological); acceptable costs of application and minimal amounts of wastes. Many decontamination methods and techniques are available that would facilitate operation, inspection, maintenance, modification or decommissioning of nuclear installations(3,4). The selection of an appropriate procedure is an important task for policy makers of national nuclear energy programs and especially for operators of nuclear installations. Removal of contaminants from metallic surfaces depends on many physico-chemical variables that govern the process of contamination. Among them the nature of the surface is the most important factor (i.e permeability, film formation, age and chemical composition of the oxide layer [5]). Other factors should be considered such as the base material and contamination history. Chemical decontamination processes are generally necessary where metal or oxidized surfaces have become contaminated[6,7]. In general, decontamination of buildings and structures, except for decommissioning purposes, should be accomplished so as to avoid airborne contamination and thus protect personnel from hazards due to dust inhalation and external contamination during operating and maintenance work. Most of these methods are usually mechanical methods such as water jetting, abrasive techniques, etc.

MATERIALS AND METHODS

The activity of radionuclides before and after decontamination was measured by using calibrated surface contamination monitor type **Berthold LB 1210 B** and the contaminated area was determined**.**

Swabbing, washing, scrubbing and brushing were used for decontamination of floors and walls of the contaminated area. The decontamination is achieved by the following process:

- The painted surface of the contaminated wall swabs from out to in by towel wetted with water.
- Mechanical action of brushes and swabs, in combination with an adequate solvent (Ethyl Alcohol $C_2 H_5 OH$) .
- Dilute chemical decontamination 1% $KMnO_4$ followed by 1% Ethylene-Diamine-Tetra-Acetic acid (EDTA) was used[8].

Solid and liquid of radioactive wastes produced from the decontamination process were segregated and collected in a plastic containers and the activity level on the surface of these container was measured.

Total Effective Dose Equivalent (TEDE) calculated by using Decontamination and Decommissioning (D&D) computer code version 2.1.0. This code[9] implements the methodology and information contained in NUREG/CR-5512, Volume 1 as well as the parameter analysis in Volume 3 that established the probability distribution function (pdfs) for all of the parameters associated with the scenarios, exposure pathways and models embodied in D&D. Two scenarios are implemented in D&D: building occupancy and residential. In our case building occupancy scenario relates volume and surface contamination levels used to estimates the total effective dose equivalent (TEDE) received during a year of exposure with the conditions defined in the scenario. This scenario accounts for exposure to fixed and removable to thin layer or surface contamination sources within a structure. The building occupant is defined as a person who works in a commercial building following license termination. The pathways that apply to the building occupant include:

- External exposure to penetrating radiation from surface sources,
- Inhalation of resuspended surface contamination, and
- Inadvertent ingestion of surface contamination.

The Building Occupancy Scenario Model

The building occupancy scenario model includes eight parameters:

External dose rate factor for exposure from contamination uniformly distributed on surfaces, $DFES_j$ (mrem/h per dpm/100 cm^2)

- Inhalation committed effective dose equivalent (CEDE) factor, DFH_j (mrem/pCi inhaled)
- Ingestion CEDE factor, DFG_j (mrem/pCi ingested)
- Length of the occupancy period, t_{to} (d)
- Time that exposure occurs during the occupancy period, t_o (d)
- Resuspension factor for surface contamination, RF_o (m^{-1})
- Volumetric breathing rate, V_o (m^3/h)
- Effective transfer rate for ingestion of removable surface contamination from surfaces to hands, from hands to mouth, GO (m^2/h)

The length of the occupancy period (t_{to}), the time that exposure occurs (t_o), and the effective transfer rate for ingestion (GO) are behavioral parameters. The volumetric breathing rate (V_o) is a metabolic parameter. The committed effective dose equivalent factors and the resuspension factor are physical parameters. As discussed below, the committed effective dose equivalent factors are classified as physical parameters because their values depend on the source geometry and contaminant solubility class.

The annual TEDE for a parent radionuclide in the building occupancy scenario $TEDEO_i$ is calculated as a sum of:

- external dose resulting from external exposure to penetrating radiation from the surface sources represented by the parent and daughter (if any) radionuclides, $DEXO_i$;
- CEDE for inhalation resulting from inhalation of resuspended surface contamination represented by the parent and daughter (if any) radionuclides, DHO_i
- CEDE for ingestion resulting from inadvertent ingestion of surface contamination represented by the parent and daughter (if any) radionuclides, DGO_Q.

The mathematical formulation of the above is (NUREG/CR-5512, Vol. 1, p. 3.14[10]):

$$TEDEO_i = DEXO_i + DHO_i + DGO_i$$

$DEXO_i$, DHO_i, and DGO_i are calculated using the average annual surface activity per unit area of the parent, C_i, and daughter radionuclides, C_j, during the first year of the building occupancy scenario. Although ingrowth of daughter nuclides may, in some cases, cause TEDE to increase with time, in the default scenario model the maximum TEDE is assumed to occur during the first year of the scenario to simplify the analysis.

Calibration of The Contamination Monitor (Berthold LB 1210 B)

Calibration was performed at Secondary Standard Calibration Laboratory (SSDL) at the National Institute for Standards, Cairo, Egypt. It was compared by a calibrated instrument (Automess-6150) which was used for relative calibration. In the calibration process a standard point source Cs-137 with activity 2.2 x 10^9 Bq placed at 9 cm. The correction factor for the instrument used is 1.088 [11]

RESULTS AND DISCUSSION

ACTIVITY LEVEL MEASUREMENT

The activity of radionuclide was measured before and after decontamination at a distance about 10 cm from the contaminated area. The decontamination factor was calculated and the data are represented in table 1. From this table it is clear that the decontamination factor is very high value for both wall and floor. This means that high efficiency decontamination process has been carried out and this is may be due to the presence of active group in the polar solvent (-OH, -COOH, $-NH_2$ groups) that makes chelation and adsorption of radioisotopes. Also, the volume of radioactive liquid and solid wastes that produced was very low.

Table –1- The activity level before and after decontamination

Contaminated Place	activity level Bq/cm^2		decontamination factor (DF)
	Before decont.	After decont.	
Wall	1400	8	175
Floor	2000	10	200

Total Effective Dose Equivalent (TEDE) before and after decontamination

Total Effective Dose Equivalent (TEDE values (mSv/yr) for all pathways, external, inhalation and ingestion before and after decontamination was calculated using D&D computer code version 2.1.0 and the data are present in table 2. This table shows that, the doses received from external exposure - before and after decontamination- is greater than that received from inhalation or ingestion. Also, the doses received from the floor is higher than that from the wall, this may be due to the concentration of radionuclide –before and after decontamination - on the floor greater than that on the wall.

Table-2- Total effective dose equivalent values before and after decontamination

Contaminated place	Dose (mSv/yr)							
	Before decontamination				After decontamination			
	All pathway	External	inhalation	Ingestion	All pathway	external	inhalation	ingestion
Wall	3.05E 0	1.18E 0	1.1E 0	8.77E-1	1.82E-2	6.73E-3	6.45E-3	5.01E-3
Floor	4.35E 0	1.68E 0	1.6E 0	1.25E 0	2.27E-2	8.41E-3	8.06E-3	6.26E-3

Table-3- Reduction factor due to decontamination (ratio of exposure values before and after decontamination)

Contaminated place	All pathways	External	Inhalation	Ingestion
Wall	168	175	171	175
Floor	192	200	199	200

Radioactive wastes produced from the decontamination process (disposal gloves, tissue paper, some pieces of cotton) were collected in a plastic container and the dose rate on the surface was measured and it was 0.02 μSv/h. This value is accepted according to Egyptian and international regulations(12) . The total weight of the solid radioactive wastes was about 0.5 kg, while the volume of the liquid wastes was about 0.25 L.

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