DOSIMETRY PRACTICES AT THE RADIATION TECHNOLOGY CENTRE (GHANA)

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ABSTRACT

Dosimetry practices undertaken to support research and pilot scale gamma irradiation activities at the Radiation Technology Centre of the Ghana Atomic Energy Commission are presented. Fricke dosemeter was used for calibrating the gamma field of the gammacell-220. The Fricke system and gammacell-220 were then used to calibrate the ethanol chlorobenzene (ECB) dosemeter. The Fricke and ECB dosemeter systems have become routine dosemeters at the centre.

Dosimetry work has covered a wide range of research specimens and pilot scale products to establish the relevant irradiation protocol and parameters for routine treatment. These include yams, pineapple explants, blood for feeding tsetse flies, cocoa bud, wood and cassava sticks. Pilot scale dosimetry studies on maize, medical devices like intravenous infusion sets and surgical gauze have also been completed. The results and observations made on some of these products are presented.

Keywords: *Radiation, dosemeters, dose, dose uniformity ratio, dosimetry, fricke*

INTRODUCTION

A pilot scale gamma irradiation facility was installed at the Radiation Technology Centre of the Ghana Atomic Energy Commission (GAEC) in March 1994, with an initial activity of 50 kCi of Co-60 [1]. The International Atomic Energy Agency (IAEA) donated this Hungarian designed facility under a Technical Cooperation Agreement No. GHA/8/004. The facility was for research into radiation processing applications with emphasis on pilot scale studies into problem areas already addressed during laboratory studies. For instance, the mass release of sterile tsetse flies into the environment, for the purposes of eradicating the trypanosomes, required sterile blood for feeding the flies. Live male flies are also sterilized before release to the wild. Food preservation through radiation processing has already received laboratory attention.

Other research activities relating mainly to the industrial applications such as the modification of polymer-based materials, wood, plastics, treatment of industrial liquid waste, etc. were to be carried out. Sterilisation of medical devices, materials and pharmaceuticals was also to be investigated. Such intended multiple utilisation of the facility require equally, multiple dosimetry procedures to establish the right doses to the specimen or products and this has been the major concern of the centre for the past two years in operation.

MATERIALS AND METHODS

The facility used for the calibrations was the gammacell-220 unit supplied by the Atomic Energy of Canada Limited under an IAEA technical agreement in October 1971. The initial installed activity was 7500 Ci of Cobalt-60. The radiation field of the gamma cell was studied using the Fricke dosemeter. The readout system for the Fricke was a German made M42 UV – spectrophotometer. Temperature corrections for the dose delivered were made using values obtained with an electrotherm TM99A digital thermometer.

The Fricke dosemeter system and the gammacell-220 were then used to calibrate the ethanol chlorobenzene dosemeter (ECB), which uses the Hungarian built Oscillotitrator type OK 302/2 as its readout instrument. In order to determine the delivered doses, the response of the irradiated ECB were compared with those earlier on calibrated and provided to us by the suppliers of the facility. The ECB and Fricke systems were then used in mapping out the dose distribution inside the irradiation chamber of the pilot scale facility.



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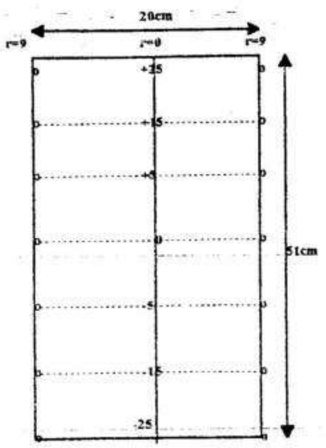

Figure 1(a) : Diagram showing the placement of dosemeters in the inner chamber

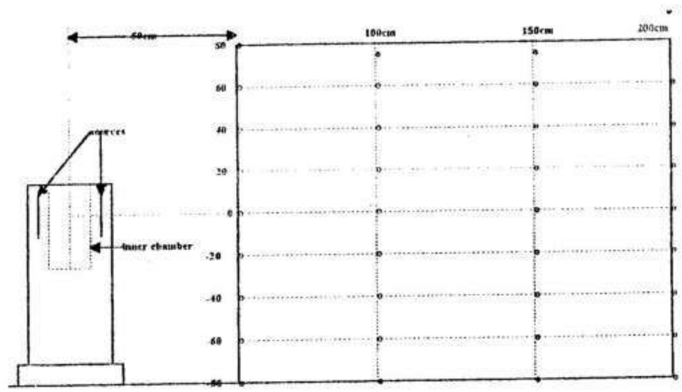

Figure1 (b): Diagram showing the placement of dosemeters in the outer chamber

The placement of dosemeters for this study were made with reference to Figures. 1(a) and (b). The results were used in setting the irradiation processing parameters for treating products at the facility.

For each type of product meant for irradiation, either a dummy or a real sample was irradiated with a number of dosemeters fixed at defined positions inside and outside the packaging. The evaluation of doses in this way revealed the dose distribution within the product and how they relate to the dosemeters fixed on the outside. In practical situations this correlation between the two sets of dosemeters enable doses received inside the product to be determined without necessarily placing dosemeters inside the product.

With the maize, three vertical sticks with dosemeters fixed at 10cm distances apart along its length were stacked vertically in the front, middle and rear ends inside the sack. This enabled dose distributions at various position inside the sacks to be obtained.

In the case of pineapple explants in media, the doses requested were relatively low and close to each other (i.e. 10-60 Gy). Consequently, media preparations similar to those housing the explants were made. Dosemeters were then placed at positions expected to be occupied by the explants and irradiation carried out. In this way the actual doses to the specimen were predicted for the irradiation of the pineapple explants.

Whole yam tubers were prepared by drilling holes at predetermined positions to house Fricke dosemeter ampoules. The yams were packed in rectangular containers measuring 50cm (Length) x 36cm (Breadth) x 26cm (Height). In cases where the expected positions for dosemeter in the yams could not be obtained because of their irregular sizes and shapes, such positions were ignored. Generally there were 27 dosemeter positions inside the yams packed into the container. Other dosemeters were placed on the outside of the containers to be able to relate doses in air on the containers to doses absorbed by yam tubers inside the container. Six of these boxes (considered as 2 sets of 3) were stacked in the vertical column and irradiated at a radial distance of 150-200cm from the centre of the inner chamber for 1 hour (split into 4 cycles of 15 minutes irradiation). After each cycle, a clockwise rotation was made about the vertical axis. After 30min., a clockwise rotation followed by a vertical displacement was made. In the vertical displacement, the 2 sets of boxes were swapped for the top one to come down. Rotation and vertical displacement during irradiation helps to obtain a better dose uniformity ratio.

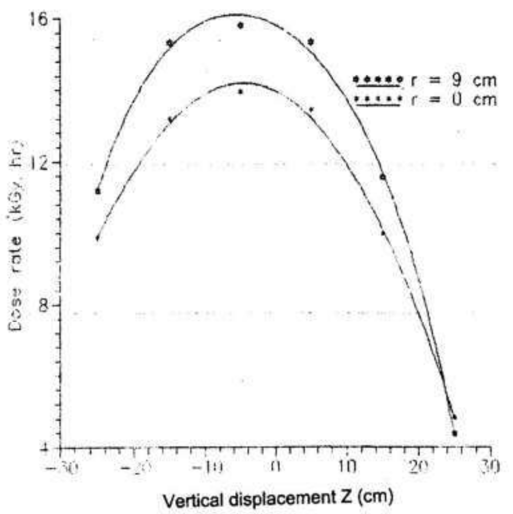

Figure 2: Dose rate as a function of vertical displacement for the inner chamber

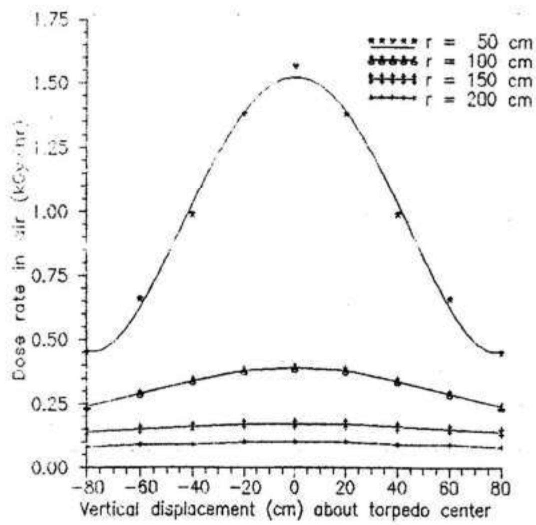

Figure 3: Dose rate distribution for the outer chamber

Dummy boxes measuring 50cm (Length) x 50cm (Breadth) x 43cm (Height), were filled with sawdust and dosemeter arrangements similar to that used for the yams. The density of the dummy boxes was 0.18 g/cc (just like most medical devices treated at the centre). Four of these boxes were stacked in the vertical column as against 6 boxes used for the irradiation of yams. Again the inside dosemeter readings were compared with those outside the boxes. Routine irradiation is then carried out with dosemeters fixed on the outside but results used to predict dose delivered to products. Due to the size of the dummy boxes, the number of dosemeters was increased to 45 in order to have a fair dose distribution within each box.

RESULTS AND DISCUSSIONS

With the aid of the Fricke dosemeter system [3, 4], it was established that the dose rate at the centre of the gammacell-220 was 201 $\pm$ 7 Gy/h. Isodose curves obtained revealed that within a radius of 1.75cm and a displacement of 4.5cm the dose rate is practically uniform about the center of the gammacell. Calibration curves were also obtained for the ECB dosimetry system.

Figure 2 presents air equivalent dose rate distribution for the inner field of the SLL-02 facility. The first column indicates the position (z) of the dosemeters for the centre of symmetry of the inner irradiation chamber. We observed that the dose rate distribution in a horizontal plane are very high as one moves outwards in a radial direction from r = 0cm to r = 9cm. This is because the torpedoes are located at a distance of about r = 12cm so that the effect of the radiation sources are significant at r = 9cm as compared to r = 0cm. We also observe in the vertical plane that the dose rate readings are almost a reflection about the z = 0 indicating the symmetry of the high radiation field inside the inner chamber.

Figure 3 gives the does rate distribution outside the inner chamber but within the processing room.

From the figure we conclude that the centre of symmetry of the torpedoes at the irradiation position is 75cm above the floor of the chamber as against the 80cm specified by the supplier [2]. This difference may probably be due to the modifications undertaken by the experts during the installation and source inventory procedures.

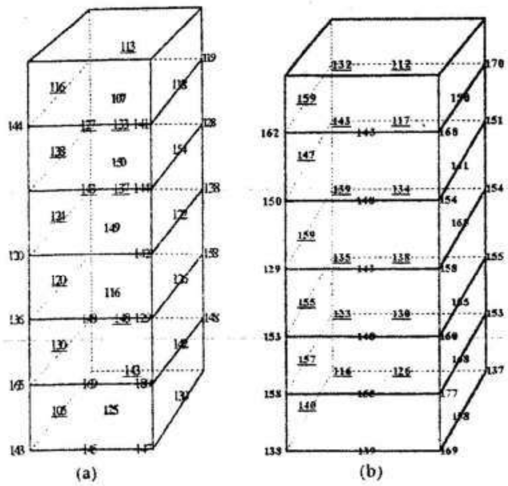

Figure 4: Dose distribution map (a) inside yam tubers (b) on boxes housing the yam tubers in one set of three boxes stacked in the vertical column

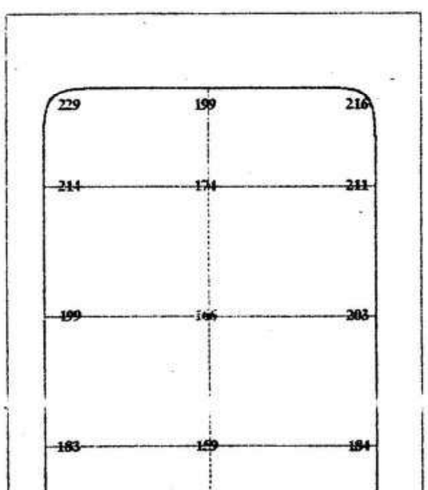

Figure 5: Dose distributions inside maize bags

In figure 4(a), dose values for dosemeters inserted inside fresh yams at specified locations are presented. The dose uniformity ratio was 1.68. This result agrees with most practical situations. Figure 4 (b), presents the doses outside the crates during the same period of irradiation. We observe that the readings are generally higher as compared to dosemeters fixed inside the yams. An important observation made in this study was the trend between dose values of reference positions on the outside boxes as they relate to doses delivered to the yams. This enables dose estimation inside the yams to be made with respect to dosemeters placed at the reference positions outside the boxes. Observations made for the dummy boxes representing sterilization of medical products were just similar to that of the yams. The dose uniformity ratio obtained was 2.24.

Dose distributions inside the maize bags are presented in Figure 5. The density of the maize was 0.76 g/cc and the dose uniformity ratio obtained was 1.51.

Irradiation work performed on some products are presented in Table 1. Doses below 40 Gy (e.g. pineapple explants and cocoa bud wood irradiations) were computed form Fricke measurements earlier on undertaken.

Table 1: Expected dose and dosemeter used for various products irradiated at centre

Product	Dose Expected	Dosemeter
Yam	150 Gy	Fricke
Maize	300 Gy	Fricke
Pineapple explants	10-60 Gy	Predicted from Fricke
Cocoa bud wood	15 Gy	Predicted from Fricke
Cocoa beans	1-10 kGy	ECB
Blood	1.5 kGy	ECB
Medical supplies	25 kGy	ECB

CONCLUSIONS

The irradiation protocols and parameters for effective and efficient radiation processing covering research and pilot scale products have been established for the most common items brought to the centre for treatment.

The swapping and rotation of products at predetermined interval helps to achieve relatively low values of dose uniformity ratio in most cases.

For doses below 40 Gy (e.g. in pineapple ex plant and cocoa bud-wood irradiations) a different dosimetry system has to be identified to enable practical dose assessment to the products instead of interpolation. The Lithium fluoride (LiF) thermoluminesence dosimeter may be helpful.

ACKNOWLEDGEMENT

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