Journal of Medical Sciences

ISSN 1682-4474

OPEN ACCESS Journal of Medical Sciences

ISSN 1682-4474
DOI: 10.3923/jms.2018.103.107

Research Article

Assessment of Exposure Dose Due to Radioactive Sources at Lab of Radiology Department-Qassim University

[1]Abdurrahman Abdullah Saad Alsayyari, [1,2]Mohammed Ahmed Ali Omer and [3]Atef. El-Taher

[1]College of Applied Medical Science, Department of Radiologic Technology, Qassim University, P.O. Box 6800, 51452 Buraidah-KSA
[2]College of Medical Radiologic Science, Sudan University of Science and Technology, Khartoum-Sudan
[3]Department of Physics, Faculty of Sciences, Al-Azhar University, 71524 Assiut, Egypt

Abstract

Background and Objective: Since radioactive elements have been extensively utilized in research centers and academic institutions, the survey assessment has been carried out to determine the activities, exposure dose at 10, 20 cm and the committed dose by trainee during practical h. **Materials and Methods:** The method depends on experimental measurement using Geiger Muller survey detector. The radioactive sources possessed by the lab were two ^{137}Cs sources, ^{90}Sr and ^{204}Ti. The activity doses at 10 and 20 cm were 19.78 and 10.86 mSv/h for g-radiation and 17.4 and 8.6 mSv/h for b particles respectively from ^{137}Cs (provided at 2012) and the exposure dose at same distances from ^{137}Cs (provided in2011) were 13.14 and 8.37 mSv/h, respectively as gamma radiation and 5.59 and 3.49 mSv/h as b particles exposure respectively, the b particles emitter (^{204}Ti) (provided in 2010)gives exposure doses at specified distances as 6.45 and 2.73 mSv/h, respectively and as well (^{90}Sr) (provided in 2011) gives exposure doses as 2.59 and 1.90 mSv/h, respectively. The exposure doses versus distances fitted to exponential equation and concise with inverse square law. **Results:** The summated g-radiation exposure doses from all sources at 10 and 20 cm were 65.84 and 19.23 mSv/h, respectively and from b particles were 32.03 and 16.72 mSv/h, respectively. Relative to MPD of the eye lens, gonads, skin and workers of the field (occupational), the exposure doses at 20 cm will represent 0.03, 0.04, 0.01 and 0.2%/h, respectively and the exposure dose received by trainee 2 h/day for fourteen practical h will result in 0.84, 1.12, 0.28 and 5.6% of the MPD for respective anatomical structures. **Conclusion:** The radioactive elements possessed by different institutions which utilized for researches, experiments should not considered as hazard less, as the accumulated doses as a function of time could increases or stimulating the radiation sickness for the eyes and skin or stimulating other potential stochastic effects.

Key words: Radio nuclides, accumulated dose, trainee, exposure, hazards, stochastic effects

Citation: Abdurrahman Abdullah Saad Alsayyari, Mohammed Ahmed Ali Omer and Atef. El-Taher, 2018. Assessment of exposure dose due to radioactive sources at lab of radiology department-qassim university. J. Med. Sci., 18: 103-107.

Corresponding Author: Atef. El-Taher, Department of Physics, Faculty of Sciences, Al-Azhar University, 71524 Assiut, Egypt

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Radioactive sources have been utilized extensively after the discovery of x-ray and radioactivity by Wilhelm C. Rontgen in 1895 and Henri Becquerel (1896), respectively[1,2]. It expanded from academic laboratories where physical characteristics of radiation as well as effects of radiation on humans, animals, plants or materials were studied to the broad use in industry, medicine and research. The common applicable radionuclides in hospitals imply the Technetium-99 m (^{99m}Tc), Iodine-131(^{131}I), Iodine-125 (^{125}I), Iodine-123(^{123}I), Flourine-18(^{18}F), Tritium (^{3}H) and Carbon-14(^{14}C)[3] which have been utilized for diagnostic purposes in addition to Cobalt-60 (^{60}Co), Storontium-90 (^{90}Sr), Cs-137 (^{137}Cs), Iridium-192 (^{192}Ir), Tilinium-204 (^{204}Ti), Sodium-24 (^{24}Na), Xenon-133, Selenium-75, Strontium-89, Phosphorus-32 that have a role in treatment issues and researches. Of course the entire radioactive sources with exposure level exceeding the permissible level have to be registered at the national and international energy commission with proper registered license, while the un-registered sources could be located at research institutions, universities, industry and state institutions with registration limited to the commercialized institution and the quality control unit of the applicable organization. The stringent control of radioactive elements should follow the principles recommended by International Commission for Radiation Protection in order to assure their safe usages[4]. The applications of radio nuclides where ever, will contributing in radiation exposure to public, student trainee, medical, environment in case being thrown before 10th. Half-life, hence eventually will exceed the prescribed safe limits. In comparison with the study carried out by Salama *et al.*[5] in Saudi Arabia, their study focused on the occupational exposure and the protection of medical staff i.e., during radiation examination. In which they concluded that: There was significant correlation between the exposure level and required imaging test as well the waiting duration in the waiting room and CT scan. In addition the utilization of shielding accessories in hospitals, which were only 50% used lead glass and shield and 57.7% use personal dosimeters as 57.7%. While Matori *et al.*[6] they determine the mean Kerma-Area Products (KAP) for abdomen, head, pelvis and thorax which were as: 243.1, 107.3, 39.05 and 45.7 Gycm^{2} respectively during interventional radiography. As well as Nassef and Kinsara[7] they focused on the average effective doses per year received by workers of diagnostic radiology, nuclear medicine and radiotherapy which were 0.66, 1.56 and 0.28 mSv, respectively. Hence, this study has unique focus that concentrates on the experimental radioactive sources used in universities' laboratories and research centers which are also represent sources contributing in annual exposure dose to special categories among the community.

In addition to expected exposure dose that may exceeds the limit, other potential hazards turn the attention of quality control committee is the lost or misplacement of the radio nuclides in the lab, which may also contribute significantly in the exposure dose and eventually causing radiation thickening for the staff, trainee or public.

Therefore a survey quality control and study of radioactive sources at laboratories of institutions dealing with researches, academic or medical purposes must be as inevitable matter so as to permit the follow up of exposure level at different locations compared with the maximum permissible dose (MPD) within the lab, radio nuclides half-lives, the types of radiation emitted and the perfect secure storage and location which will be the focus of current research.

MATERIALS AND METHODS

Tools and equipment: The tools used in this study have been shown in Fig. 1, 2 specifically as:

- Radiation survey meter (RedEye B20-version-2,19V E.2.05/2012-09-07), for α, β, γ-radiation with By virtue of optional gamma energy filters, deep or shallow dose rate measurements from 17-1300 KeV can be performed
- Filter Al. foil for β absorption
- Holder: Highest from 0-70 cm
- Scale meter
- Radioactive elements (Cesium "^{137}Cs (two sources)", Strontium "^{90}Sr", Tilinium"^{204}Ti")

Method and techniques: In Qassim University and at the physics lab of radiology department during April 1, 2017-May 20, 2017 the measurement of this study took place. A holder has been mounted on the bench at the lab to which a radiation survey meter has been tide to arm with an adjustable screw to obtain variable distances (10-100 cm).

Then a radioactive element ^{137}Cs (two sources), ^{90}Sr, ^{204}Ti, have been put under the survey meter at different distances (30, 40, 50, 60 and 70 cm) with and without added Al filter which isolated the beta radiation and measure the radioactivity as pure γ-radiation which is equal to (Dose

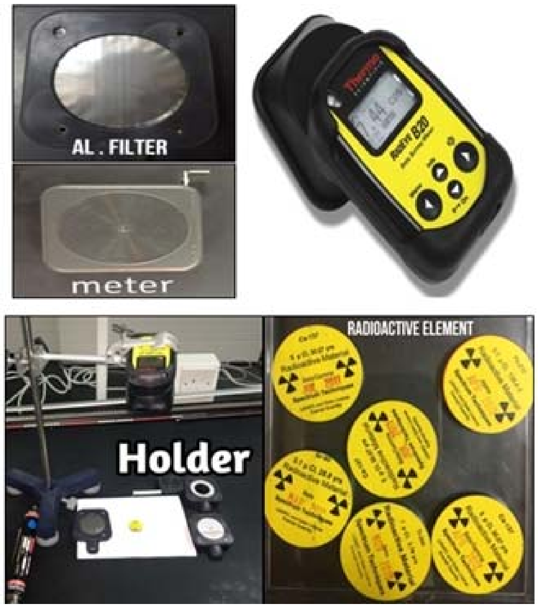

Fig. 1: Aluminum filter, holder with adjustable screwed arm, radioactive sources and radiation survey detector (RedEye B20-version-2,19V E.2.05/2012-09-07)

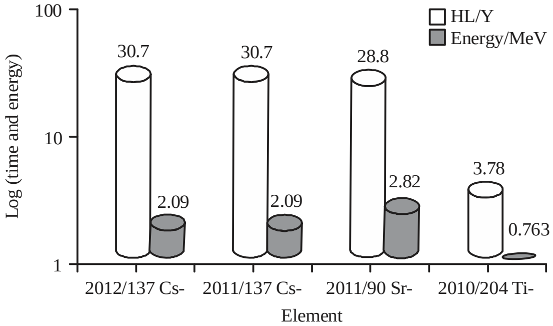

Fig. 2: Types of radioactive elements in the lab with relative Energies, half-life and the year brought to lab, as recommended orientation sign at the storage lead box for radioactive elements at the lab

without filter-the dose with filter) for all radioactive elements in 2016. Then the doses in (mSv) have been plotted versus distances in cm.

RESULTS

The following section deals with highlighting of radioactive elements in radiology laboratory department specifically showing their: Energies, half-life (HL) as in (Fig. 2), which is recommended to be posted at the storage box of radioactive elements at the lab as orientation sign, exposure dose versus distance for each radioactive element (Fig. 3-6) to deduce the dose received by trainee student at any point in the lab and the average received dose per year by the trainee student in the lab at 10 and 20 cm (Fig. 7).

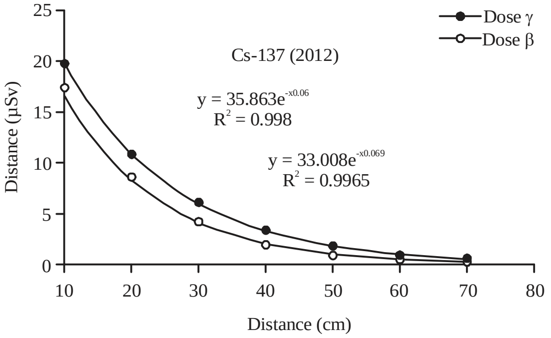

Fig. 3: Correlation between dose µSv/h and distance cm for Cs-137 that provided to radiology lab 2012, shows the variation of individual trainee student at different distances from the radioactive sources at the lab

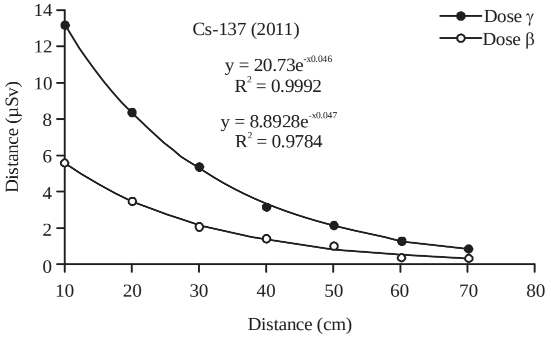

Fig. 4: Correlation between dose µSv/h and distance in cm for Cs-137 that provided to radiology lab 2011, shows the variation of individual trainee student at different distances from the radioactive sources at the lab

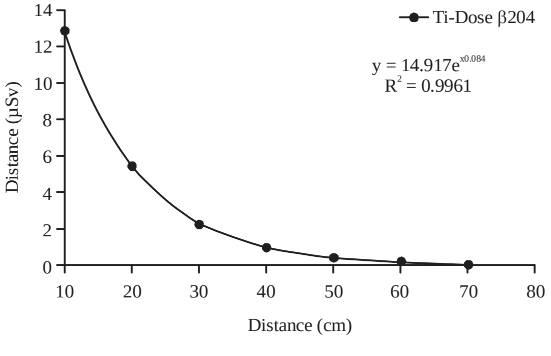

Fig. 5: Correlation between dose µSv/h and distance cm for ^{204}Ti that provided to radiology lab in 2010, shows the variation of individual trainee student at different distances from the radioactive sources at the lab

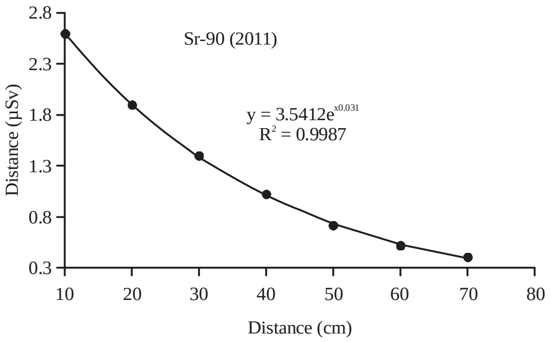

Fig. 6: Correlation between dose µSv/h and distance cm for ^{90}Sr that provided to radiology lab 2011, shows the variation of individual trainee student at different distances from the radioactive sources at the lab

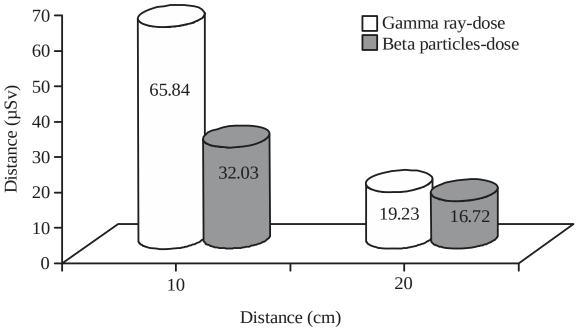

Fig. 7: Average measured dose in µSv received at 10, 20 cm from γ-radiation and β-particles, as expected dose to be received by student trainee at the lab

The type of radioactive elements found in the lab with relative Energies and half-life shown in (Fig. 2) which indicated that, there were two sources of ^{137}Cs with an imported date to lab in 2012 and 2011, in addition to ^{90}Sr and ^{204}Ti with their energies of 2.82, 2.09, 0.763 MeV and the HL 30.7, 28.8, 3.78, respectively. These radioactive elements consider being friendly environment by 10th. HL i.e., in the years 2319, 2318, 2299, 2048 based on the fact stated that "friendly environment only occur after elapsed 10th HL" at which only less than 0.1% of the parent radioactivity remain[8] and such plotting categorization of radioactive elements has been based on activity, form and half live as stated by Khan *et al.*[3]. The activity doses at 10 and 20 cm were 19.78 and 10.86 mSv/h, asg-radiation and 17.4 and 8.6 mSv/h for b particles, respectively from (^{137}Cs-2012). Such doses have been decreased following the distance increment in a form fitted to the following equations:

$$y = 35.863e^{-0.06x}$$

for gamma radiation and:

$$y = 33.008e^{-0.069x}$$

for b particles where, x refers to distance in cm and y refers to dose in mSv (Fig. 3) and the correlations were significant at $R^2 = 0.9$, which is also follows the law of inverse square and with respect to b radiation dose it was about to vanish at 100 cm. However, the strength and the dose amount of gamma radiation was greater than b radiation along the entire distance which could be ascribed to the fact that gamma radiation has longer range and can't stopped unless using lead shield in contrast with b radiation that could be limited by a foil of aluminum or distance. Same disintegration process has been obvious for ^{137}Cs which provided to lab in 2011(Fig. 4), however the exposure dose at 10 and 20 cm distance were 13.14 and 8.37 mSv, respectively as gamma radiation and 5.59 and 3.49 mSv as b particles exposure respectively which in turn being decreased following the distance in cm increment that fitted to the following exponential equations:

$$y = 20.73e^{-0.046x}$$

for gamma radiation and:

$$y = 8.8928e^{-0.047x}$$

for b particles exposure, where, x refers to the distances and y refers to exposure dose in mSv. For the radio nuclide ^{204}Ti that provided to radiology lab in 2010, which emits (b) radiation (Fig. 5), it shows same reduction of dose versus distance in a correlation fitted to equation of the form:

$$y = 14.917e^{-0.084x}$$

with an exposure dose 6.45 and 2.73 mSv at 10 and 20 cm, respectively. And as well, ^{90}Sr that provided to radiology lab in 2011 (b particles emitting source) (Fig. 6), it shows same manner of exponential decreasing dose versus distance fitted to equation:

$$y = 3.5412e^{-0.031x}$$

and it is exposure doses at 10 and 20 cm were 2.59 and 1.90 mSv, respectively. With respect to continuous quality control at radiology labs, these radio nuclides have to be stored in separate lead container with the yellow surface facing upwards during handling and storing as it contains a lead sheet, however the QC process revealed random positioning and storing of radio nuclides with negligible handling which may lead to considerable exposure to student trainees during their presence at lab where they did not aware about the presence of radio nuclides. From general estimation, the summated g-radiation exposure doses from all sources at 10 and 20 cm were65.84 and 19.23 mSv, respectively and the exposure doses from b particles at 10 and 20 cm were 32.03 and 16.72 mSv, respectively (Fig. 7). With consideration to MPD of the eye lens, gonads, skin and workers of the field (occupational)[9,10], the exposure doses at 20 cm will represent 0.03, 0.04, 0.01 and 0.2% per hour, respectively. Such results could offer enquiring about the total committed exposure dose for the trainees who work for at least two h/day for fourteen practical days during the semester, which will result in 0.84, 1.12, 0.28 and 5.6 of the MPD for respective anatomical structures. These committed exposure plus other factors that may induce or stimulate the lens cataracts (protein denaturation due to aging, metabolic changes, injury, radiation, toxic chemicals or drugs)[11] and with consideration to additional practical h of the trainees at hospitals and clinics, there could be an increasing probability of radiation sickening such as lens's cataracts, temporary sterility, erythema and total body diseases.

CONCLUSION

Radioactive elements (Storontium-90 (^{90}Sr), Cs-137 (^{137}Cs), Iridium-192 (^{192}Ir), Tilinium-204 (^{204}Ti), Sodium-24 (^{24}Na), Xenon-133, Selenium-75, Strontium-89, Phosphorus-32) possessed by different institutions for treatment, diagnosis and experimental researches, although some have been utilized with low activity however could not be considered as hazardless, since the accumulated doses as a function of time could increases or stimulating the radiation sickness for the eyes and skin or stimulating other potential stochastic effects.

SIGNIFICANCE STATEMENT

The significance of this study will reveals the potential hazards of accumulated radiation exposure such as eye cataracts and other radiation sickening from experimental radiation sources utilizing in different institutions.

REFERENCES

1. Stewart, C.B., 2013. Radiologic Science for Technologists: Physics, Biology and Protection. 10th Edn., Mosby Inc., (Elsevier Inc.), USA.
2. James, D.C. and K. Kina Ang, 2010. Radiation Oncology: Rationale, Technique, Results. 9th Edn., Mosby Inc., (Elsevier Inc.), Philadelphia, USA.
3. Khan, S., A.T. Syed, R. Ahmad, T.A. Rather, M. Ajaz and F.A. Jan, 2010. Radioactive waste management in a hospital. Int. J. Health Sci., 4: 39-46.
4. Janzekovic, H. and M. Chrisman, 2007. Radioactive sources in chemical laboratories. Proceedings of the International Conference Nuclear Energy for New Europe, September 10-13, 2007, Portoroz, Slovenia, pp: 1-8.
5. Salama, K.F., A. Al-Obireed, M. Al-Bagawi, Y. Al-Sufayan and M. Al-Serheed, 2016. Assessment of occupational radiation exposure among medical staff in health-care facilities in the Eastern province, Kingdom of Saudi Arabia. Indian J. Occup. Environ. Med., 20: 21-25.
6. Matori, M.K., H. Salleh, M.J.M. Isa, M.A.J. Sidek and M.H.F. Ahmad *et al*., 2014. Assessment of patients radiation dose during interventional radiological procedure in PPUKM. Proceedings of the Research and Development Seminar, October 14-16, 2014, Bangi, Malaysia, pp: 1-6.
7. Nassef, M.H. and A.A. Kinsara, 2017. Occupational radiation dose for medical workers at a university hospital. J. Taibah Univ. Sci., 11: 1259-1266.
8. IAEA. and ICRP., 2009. Release of patients after radionuclide therapy. Safety Reports Series No. 63, International Atomic Energy Agency, Vienna, Austria.
9. Bolch, W.E., G. Dietze, N. Petoussi-Henss and M. Zankl, 2015. Dosimetric models of the eye and lens of the eye and their use in assessing dose coefficients for ocular exposures. Ann. ICRP., 44: S91-S111.
10. Broughton, J., M.C. Cantone, M. Ginjaume and B. Shah, 2013. Report of task group on the implications of the implementation of the ICRP recommendations for a revised dose limit to the lens of the eye. J. Radiol. Prot., 33: 855-868.
11. Spyratou, E., A. John, P. Kalliopi, B. Constantinos, M. Mersini, S. Alexander and E. Efstathios, 2017. Investigating the effect of ionizing radiation on intraocular lenses at clinical doses. Insights Med. Phys., Vol. 2, No. 2.