Mathematical calculation of effective dose From gamma ray sources in nuclear physics lab.

The aim of the project is to estimate amount of contamination to which the radiation worker is subjected to , and also to determine the amount of risk from the radioactive source . the parameters that which enrolled in this project is the activity of radioactive source , distance from radiation source and time of exposure . mathematical calculations were done to calculate the effective dose using mathematical equation . two point source were enrolled In this project (Co -60 & Cs – 137) of different gamma ray energy . the result obtained show the level of contamination at the time interval is within normal level .

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Introduction

Scientists have studied the effects of radiation for more than 100 years , and they know a great deal about how to detect , monitor and control even the smallest amounts . in face , more is known about the health effects of radiation than about most other physical or chemical agents .[1]

The goal of any radiation safety program is to reduce exposure , whether internal or external , to a minimum . the external exposure reduction and control measures available are of primary importance [2]

In order to be able to protect people from ionizing radiation , it obviously necessary to measure the radiation to which they may be exposed , and so quantity Exposure .

The unit of Exposure is the roentgen (R) [3] which is defined as that quantity of radiation which will release an electric charge of (2.58×10^{-4}) coulomb / kilogram of dry air , Exposure refers to amount of ionization produced in air .

Health effects of radiation exposure start with the deposition of radiation energy in cells , tissues and organs . when radiation passes through matter , it deposits energy in the material concerned .[4]

The effective dose, is a dosimetery parameter which take into accounts the dose received by all irradiated radiosensitive organs and may be taken to be measure of stochastic risk. Although the effective dose is an occupational dose quantity based on age profile for radiation workers ,this dose descriptor is being increasingly used to quantify the amount of radiation received by patients under diagnostic examinations [5].

Method of calculation:

Two radiation sources were used in this study are (^{137}Cs) which emits gamma ray photons of (0.662 MeV) with the activity of (5 µCi) and (^{60}Co) which emits two photons (1.173 & 1.333 MeV) with activity of (5 µCi) . The two sources that which used in this study of disk shape of 2 cm diameter .

The effective dose can be obtained using the following equation:[6]

$$\text{……..(1)}\quad E_{point} = \frac{A \; x \; CF_{point} \; x \; t}{distance^2}$$

Where

E_{point} = Effective dose from point source [mSv]

A = Source activity [kBq]. 1 Ci = 3.7 x 107 kBq.

CF_{point} = Conversion factor for a point source, [(mSv . m2)/(kBq . h)]

distance = Distance in meters from the point source [m]

t = Exposure duration [h]

Results:

The effective dose was calculated mathematically using equation (1) in unit of mSv/h from two radioactive sources ^{60}co and ^{137}cs for one , two and three hours. The results of calculations are listed in the Table 1 and table 2 respectively.

table (1) :

The effective dose (mSv/h) from ^{137}cs relative to the distance (m)

distance (m)	Effective dose in one Hour.	Effective dose in two houes	Effective dose in three hours
0.5	4.588×10^{-5}	9.176×10^{-5}	13.764×10^{-5}
0.6	3.186×10^{-5}	6.372×10^{-5}	9.5583×10^{-5}
0.7	2.34×10^{-5}	4.68×10^{-5}	7.0224×10^{-5}
0.8	1.79×10^{-5}	3.58×10^{-5}	5.376×10^{-5}
0.9	1.4×10^{-5}	2.8×10^{-5}	4.248×10^{-5}
1	1.147×10^{-5}	2.294×10^{-5}	3.441×10^{-5}
1.1	0.947×10^{-5}	1.894×10^{-5}	2.841×10^{-5}
1.2	0.796×10^{-5}	1.593×10^{-5}	2.3895×10^{-5}
1.3	0.6787×10^{-5}	1.357×10^{-5}	2.036×10^{-5}
1.4	0.585×10^{-5}	1.17×10^{-5}	1.755×10^{-5}
1.5	0.5×10^{-5}	1×10^{-5}	1.5×10^{-5}

table (2) :

The effective dose (mSv/h) from ^{60}co relative to the distance f(m).

distance (m)	Effective dose in one Hour.	Effective dose in two houes	Effective dose in three hours
0.5	1.85×10^{-4}	3.7×10^{-4}	5.55×10^{-4}
0.6	1.284×10^{-4}	2.569×10^{-4}	3.85×10^{-4}
0.7	0.94×10^{-4}	1.888×10^{-4}	2.83×10^{-4}
0.8	0.72×10^{-4}	1.445×10^{-4}	2.167×10^{-4}
0.9	0.57×10^{-4}	1.14×10^{-4}	1.7×10^{-4}
1	0.462×10^{-4}	0.925×10^{-4}	1.3875×10^{-4}
1.1	0.38×10^{-4}	0.76×10^{-4}	1.147×10^{-4}
1.2	0.32×10^{-4}	0.64×10^{-4}	0.96×10^{-4}
1.3	0.27×10^{-4}	0.547×10^{-4}	0.82×10^{-4}
1.4	0.236×10^{-4}	0.47×10^{-4}	0.7×10^{-4}
1.5	0.2×10^{-4}	0.4×10^{-4}	0.6×10^{-4}

Discussion

The external radiation dose calculation determines the radiation dose flow gamma ray source .The source can be appoint source , or a cylindrical volume source with an evenly distributed concentration of radionuclide [7] .

The results show the effect of the inverse square law on the effective dose , so as the distance decrease the effective dose increase significantly . so this parameter [distance] was studied by [Jeffery and carol] who interested in the distance between patient who are up take a radiopharmaceutical drug and considered the patient as portable radiation source .

Other parameter of this project was the time of the exposure that which be taken by [Tapiovaara] in his project.

Our result show that effective dose at 0.5 m from the source was for the ^{137}cs higher than that for ^{60}co and we think that due to the energy of gamma ray for ^{137}cs is lower (0.266 MeV) than that for ^{60}co (1.25 MeV)as the activity for the two sources was 5 µCi .

The idea of this project was similar to many projects whose interested in calculating the radiation absorbed dose whether it is skin absorbed dose [10] or effective dose [11] software package called the EPRI EDE Calculator that allows a user to input exposure data and to calculate the effective dose equivalent and effective dose automatically. Even it is comparable to projects that using Monte Carlo program [12] , [13] .

Also effective dose for adult patient in diagnostic radiology using Dose Cal software[14].

Conclusion and Recommendations

1.The highest effective dose that which calculated by this project was in the safe side at these time(1,2,3 hours).Similar research was done to estimate surface skin dose and deep skin dose using two method ,one of which using MCNP code (software) and practical method using phantom body from Co-60 source located at 10 cm and 30 cm [17].

2. The exposure time must be minimized as much as possible to avoid the cumulative dose from radioactive source for the workers in the lab.

3. To determine the maximum permissible dose(MPD) in (rem) for radiation worker especially the staff who are exposed for long time to radiation relative to the age in (year) I suggest utilizing the following formula [MPD =5(N-18)] [16] , N is the age in year, where the age of the staff and student are ranged from (21 to 45 year).

4.To determine the amount of dose or contamination received by staff or student ,they must have either film badge or personal dosimeter(pen dosimeter) to monitor their contamination every month or year.

5.We recommended that staff and student must be at least one meter away from the radioactive sources.

الحساب الرياضي للجرعة المؤثرة في مختبر الفيزياء النووية من العناصر المشعة لأشعة كاما .

الهدف من البحث هو تخمين كمية التلوث الذي يتعرض له العاملين في الحقل الإشعاعي و كذلك لتحديد كمية الخطر من العناصر المشعة . المتغيرات الداخلة في هذا البحث هي فعالية العناصر المشعة ، المسافة من المصدر المشع و زمن التعرض للإشعاع المنبعث من المصدر المشع . حسابات رياضية أجريت لحساب الجرعة المؤثرة باستخدام معادلة رياضية . عنصران مشعان تم أدراجهما في هذا البحث { Co-60 و Cs-137 } الباعثين لطاقتين مختلفتين لأشعة كاما . النتائج وضحت بان مستوى التلوث في الوقت المحسوب هو ضمن الطبيعي .

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