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Research Article

Calculating Dose Conversion Factor Experimentally for Cs-137 Radionuclide for Radioactive Waste at Metallic Drums

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Abstract

In the present work, calculating dose conversion factor for purpose to calculate the activity concentration for radioactive waste (RW) which contaminated by ^{137}Cs radionuclide and its putting in metallic drums depended the value of dose rate. Gamma spectrometer and relevant accessories were supplied by Canberra, USA used to measure the activity for each radionuclides in the RW and connected in characterization drum system, and used Ludlum detector device to measure equivalent dose rate. Calculated the dose conversion factor experimentally through scheme as shown in fig (1) and its value (0.0099 $\frac{\mu R/h}{Bq/kg}$).

Keywords: *Dose conversion factor, activity concentration, dose rate*

1. Introduction

Radioactive waste handling activities are hazardous as concern both contamination and external exposure. Therefore strict regulations are applied for radiation protection in this field. Dose rate in the vicinity of the waste container has to be kept below certain constraints throughout entire treatment and conditioning process. Also, during transportation and for the final storage, the dose rate should meet acceptance criteria stated by the safety regulations. On the other hand, the waste management activities are very costly and thus the final product, which is the waste form, should incorporate as much activity as possible to optimize these costs (IAEA, 2011). Conversion coefficients relating measurable, physical quantities to protection quantities can facilitate the evaluation of potential health risks to a population in the case of a radiological accident. The majority of published conversion coefficients are derived from various types, Thus, there is a need to supplement the current set of conversion coefficients, with data based upon measurements (IAEA, 2012) .

Conversion coefficient, also known as a conversion factor (CF) in the literature, relates the protectoral or operational quantities as defined by the ICRP and ICRU (ICRP 119, 2012, ICRP, 2007), to a physical quantity characterizing a radiation field. The commonly used physical quantities, either measured or calculated), tissue-absorbed dose (DT) and particle flounce (ICRP.1996) Treatment of radioactive waste may involve segregation, chemical adjustment, decontamination, containment, volume reduction, removal of radio nuclides from the waste, and change of composition. Conditioning may involve conversion of the waste into a solid form, cementation, verification, enclosure of waste in containers, and provision of an over-pack for transport.

The final product of the treatment and conditioning technology for radioactive waste (steel drum – Concrete), which is manufactured according to the external dose rate.

The main aim of the present study was to determine and calculated conversion coefficients relating the measure dose rate and activity concentration to radioactive waste putting in the drums, for the gamma energies to ^{137}Cs.

2. Experimental Work

The RW which placed in drums resulting from the decontamination of a site operations that contaminated by ^{137}Cs radionuclides. A drum characterization system (DCS) was utilized for these processes and Energy Calibration of HPGe Detector, attenuation coefficient for steel drums (Asia H, et al,2015).Tow method experimentally used in this work:

(a) 89 steel drum contain soil contaminated characterizations by DCS to measure and calculated of activity by HPGe Detector and gamma vision version (6.8) software for gamma spectrum analysis that supply to DCS and the dose rate measured by Ludlum

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radiation detector and more point on the surface of the all drum and then calculated average these measure, these value for the activity and dose rate illustrated in table (1). The activity concentrations of the location were calculated using the following analytical expression as shown in Eq.1 (O. Kamal Abdullah, 2009).

a-

$$A = \frac{\frac{N}{t} - B.G}{I\% * eff\% * m} \quad (1)$$

where:

N/t - is the net count or net area under the peak.
I - is the intensity.
Eff. - is the efficiency of the detector
t - is the counting time for each sample
m - is the mass of sample =1 Kg.
B.G - is the background

The measured activities of the sample dose note represent the actual activity value due to the loss of some photons in the passage of the photons through the steel material of the barrel. Calculated the dose conversion factor experimentally through scheme as shown in fig (1) then the calculated activity concentration from by using equation 2 .

$$dose\ rate\ \left(\frac{\mu R}{h}\right) = dose\ conversion\ factor\ \times\ activity\ concentration\ \left(\frac{Bq}{kg}\right) \quad (2)$$

(b) A total 89 samples were taken from steel drums that contain RW. The samples were dried in an oven at 120 ^{0}C for 48 hours. The samples were grinded to form powder and then sieved by a sieve of 315 μm. The samples of 500 g kept in a cylindrical container. Activity concentration of sample measured by used the stable gamma spectrometry system (germanium detector), doing the relation between activity concentration (A_C) calculated and activity concentration (A_C) measured by stable germanium detector illustrated in fig (2). Resulting equation which show relation between both activity calculated and measurement eq (3):

$$mesurment\ A_c\ \left(\frac{Bq}{kg}\right) = 0.625 \times calculated\ A_c\ \left(\frac{Bq}{kg}\right) - 679.56 \quad (3)$$

3. Conclusions

The calculations were in good agreement with the measured values of the dose rate for the set of RW considered for validation. The test case based on conversion factor showed a very good agreement of the dose rate provided by the measurements. And the using eq (3) it's the good method to measurement activity concentration that can to use and choosing the best method to conditioning RW.

Table (1): Activity concentration Bq/kg and dose rate μR/h

Drum No.	Weight (kg)	Activity concentration (Bq/kg)	Dose Rate (μR/h)	Drum No.	Weight (kg)	Activity (Bq/kg)	Dose Rate (μR/h)
1	140	87398.84393	862.9	26	230	13849.710	186
2	160	5227.745665	52	27	249	3421.9653	35
3	271	4530.635838	45	28	249	5360.6936	33.8
4	279	4306.358382	42.8	29	232	6774.5664	66.8
5	90	55248.55491	550	30	175	4446.2427	43
6	271	21040.46243	209	31	240	2462.4277	29
7	232	144161.8497	1435	32	250	4523.6994	45
8	115	21710.98266	217	33	258	5194.2196	61
9	160	34936.41618	345.8	34	228	15225.433	150.9
10	274	8323.699422	86.6	35	261	9131.7919	90.3
11	191	4426.589595	45	36	245	4027.7456	40
12	225	2984.971098	29.5	37	199	9806.9364	96.8
13	235	4501.734104	43.9	38	234	8781.5028	60
14	135	110115.6069	1092	39	264	4860.1156	51
15	129	86092.48555	854.9	40	204	3499.4219	33.9
16	185	6538.728324	65	41	250	5882.0809	77
17	125	6709.82659	66	42	240	4861.2716	47
18	203	71063.58382	700	43	224	4278.6127	40.9
19	275	41456.6474	410.8	44	213	4313.2947	41.5
20	185	43630.0578	427	45	223	2653.1791	55.5
21	235	41884.39306	420	46	242	3852.0231	37.8
22	165	57248.55491	570	47	230	8465.8959	83.8
23	238	36462.42775	360.8	48	250	4213.8728	40.9
24	173	4697.109827	68	49	208	5231.2138	52
25	223	3297.109827	31.8	50	241	6774.5664	67.5

Drum No.	Weight (kg)	Activity concentration (Bq/kg)	Dose Rate (μR/h)	Drum No.	Weight (kg)	Activity (Bq/kg)	Dose Rate (μR/h)
51	265	5187.283237	51	71	233	10175.722	99.8
52	255	5198.843931	100	72	241	15780.346	155.8
53	240	4020.809249	40	73	194	1806.9364	18
54	135	1710.982659	17	74	185	4565.3179	45
55	237	2163.00578	21.7	75	136	3404.6242	33.7
56	125	2689.017341	31	76	192	963.23699	9.5
57	240	5390.751445	53	77	247	12369.942	122
58	255	2964.16185	31	78	252	6374.5664	64
59	243	37965.31792	468	79	241	14138.728	139.9
60	225	34358.3	340.8	80	200	14242.774	140.9
61	205	37699.42	317	81	253	2364.1618	22.9
62	230	2227.745	29	82	198	6380.3468	62.8
63	226	1772.254	17.7	83	187	27456.64	271.9
64	235	1949.132	19.5	84	200	15260.11	150.8
65	238	11560.69	115	85	131	5425.433	52.9
66	211	13179.190	131.5	86	254	1379.190	13
67	230	15225.43	150	87	225	819.4219	72.25
68	216	7060.115	69.8	88	130	35352.60	350.7
69	220	8427.7456	82.7	89	265	8597.6878	84.8
70	198	14913.29	147.8				

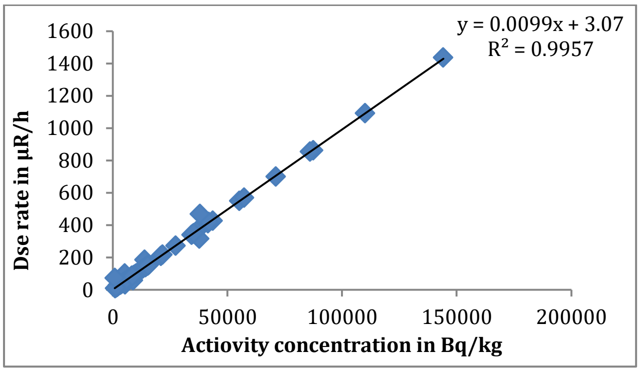

Fig.1: Relation between dose rate and activity concentration

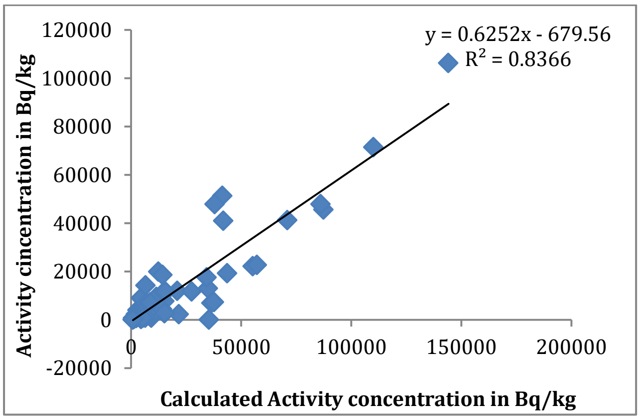

Fig.2: Relation between A_C measurements and calculated of A_C

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