Study the Radiological Assessment for Italian Radioisotops Production Laboratory (IPRL) (Tuwaitha-Iraq)

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Abstract

In order to study assessment of the annual doses and cancer risk lifetime related in IRPL laboratory, the field measurements were performed on a systematic grid .Soil samples were collected and prepared for laboratory analyzed by using gamma spectrometry system (HPGe). RESRAD software version (6.5) was used to assess the annual doses and probability of excess cancer risk lifetime incurred by workers exposed to radioactive material. The results indicated that the Total Effected Dose Equivalent (TEDE) received from artificial radionuclides IP-139, IP-79, and IP-184 are (2.116, 0.394, 10.97) mSv/y respectively are exceed the regulatory dose limit adopt by NRC (Nuclear Regulatory Commission) (0.25mSv/y) and (0.3mSv/y) of IAEA criteria, while TEDE from natural radionuclides sample (IP-15) is (0.03459mSv/y) less than the basic dose limit. The artificial radionuclides cells must be treated to keep IRPL, workers and surrounding environment within accepted limit.

Keyword:-Radiological Assessment, RESRAD, Release of Site.

Introduction

The Italian Radioisotopes Production Laboratories (IRPL) is located at the Tuwaitha site approximately 20km Baghdad south and located in the previous facility of IAEC, which is currently a affiliated to the Minister of Science and Technology (MoST), and considered a part of the nuclear complex built by Italy. The IRPL was operated in 1981 for production of radioisotopes, sources, labeled compounds, kits for medical and industrial uses and temporary storage and packing to supply the hospitals and some other organizations. This facility was dealing with irradiated materials by research reactors. Treatment of these irradiated materials occur inside two types of shielded (concrete) hot cells:

A. SC-9 (for 100 Ci Co-60 source of wall thickness 90 cm)
B. SC-10 (for 100 kCi Co- 60 source of wall thickness 125 cm) seem of very high beta/gamma activity.

These two hot cells are the only remaining structures following extensive damage of 1991.Nothing that the facility is under decommission now.

The Aim of Study

A- To ensure that the (IRPL) is clear and don't cause risks to worker, public (within Tuwaitha Site) and to the local environment.
B- To release the site of the radioisotopes laboratories for restricted or unrestricted
C- Use RESRAD (onsite) software package for radiological assessment.

Experimental

Soil samples were collected and prepared for measurements according to the methods described in references[1] and [2], analyzed using gamma spectrometry system with vertical high purity germanium (HPGe) detector of efficiency 40 %, and resolution (2.0 keV) which is normally based on the measurement of 1.332 MeV gamma ray photo peak of Co-60. Multi channel analyzer (MCA) with 8192 channel used. Both high voltage supply and amplifier device are compact in one unit (DSA 2000). A detector shield are with a cavity adequate to accommodate large samples. Calibration and efficiency of the system are carried out using multi–gamma ray standard source (MGS-5, Canberra) of Marinelli beaker geometry. The analysis are conducted by dedicated software program (Genie-2000,U.S.A), main report gain

included the line energy, net area counts, background, intensity, FWHM of identified and unidentified peaks in the spectrum, concentration for each radionuclide's detected [3]. The radionuclide's concentration data are summarized in Tables (1 and 2) were used as the basis for this analysis. RESRAD short for (RESidual RADioactivity) software version (6.5) a computer program developed by the Environmental Assessment Division of Argonne National Laboratory, first released in 1989 [4], this code is used to predict Total Effective Dose Equivalent (TEDE), probability excess cancer incidence risk incurred by worker exposed to radioactive material and derivation of soil cleanup criteria. Guidelines [acceptable level of radioactive material comply with criteria adopt by regulatory body] are based on the following principles:

1. The total effective dose equivalent should not exceed 25 mrem/y (0.25 mSv/y)
2. Doses should be kept as low as reasonably achievable (ALARA).

For this scenario potential radiation exposure pathways include:-

1. Direct exposure to external radiation from the contaminated material.
2. Internal radiation from inhalation of dust.
3. Internal of radiation from ingestion of contaminated soil.

In this case the potential exposure scenario assumed using the site without radiological restrictions. Simulations were performed for up to (60) years. Workers are supposed to perform 8 working hours daily at the site. Drinking water is assumed to come from town water supply, the worker does not ingestion any foods (plants, meat or milk) grown or raised on the site.

Results and Discussion

The artificial and natural radionuclide's concentration obtained from soil samples are listed in the Table (1) and (2) respectively.

Table (1)
The initial concentration of artificial radionuclide's in the IPRL.

Sample Code	*Initial Concentration PCi/g*		
	Cs-137	*Co - 60*	*EU-152*
IP-0	0.189	B.D.L	B.D.L
Ip-15	0.0459	B.D.L	L.D.L
IP-66	0.116	0.089	0.119
IP-72	0.991	0.227	0.121
IP-79	0.0788	11.732	1.121
IP-123	0.0129	B.D.L	B.D.L
IP-124	3.78	0.068	0.2187
IP-139	273.945	0.138	0.175
IP-151	0.0918	B.D.L	0.1674
IP-152	0.459	0.313	0.208
IP-178	0.305	B.D.L	B.D.L
IP-182	519.43	B.D.L	B.D.L
IP-184	535.1	0.212	B.D.L
IP-189	0.159	0.0486	B.D.L
IP-194	0.1566	B.D.L	B.D.L

B.D.L = Below Detection Limit.

Table (2)
The natural radionuclides concentration in the IPRL.

Sample Code	*Initial Concentration PCi/g*		
	Ra-226	*Ra-228*	*K-40*
IP-0	0.543	0.508	9.048
Ip-15	0.454	0.545	9.096
IP-66	0.2773	0.208	6.156
IP-72	0.34	0.292	5.659
IP-79	0.383	0.238	4.099
IP-123	0.378	0.313	7.395
IP-124	0.292	0.313	6.863
IP-139	0.235	0.313	4.717
IP-151	0.448	0.405	7.657
IP-152	0.329	0.363	6.791
IP-178	0.442	0.283	7.219
IP-182	B.D.L	B.D.L	4.84
IP-184	0.442	0.234	7.4
IP-189	0.378	0.397	7.53
IP-194	0.3834	0.51	8.829

According to screening calculation rule (the highest soil samples measurements) [5], samples of (IP-79, IP-139, IP-182 and IP-184) from Table (1) and(IP-15) from Table (2) were selected as represented samples for this scenario.

By using RESRAD (onsite) software (V 6.5) and concentration of samples selected, the Total Effected Dose Equivalent (TEDE) received by workers are summarize in Table (3) due to pathways considered in this scenario

Table(3)

Summerized TEDE from sample selected.

Sample code	*TEDE (mSv/y)*
IP-15	0.0346
IP-79	0.394
IP-139	2.116
IP-182	4.05
1P-184	10.97

Summary report describe in Figs. (1,3,5 and 7) which are focus on Single Radionuclides Soil Guideline (SRSG) the last column [G(I,tmax)], represented the most important pieces of information, gives the soil guideline for each radionuclide included in the contaminated samples in PCi/g and according to (Unity Rule) the Sum of Fraction for samples are calculated to check whether an actual measurements complies with clearance levels by divided initial concentration for each nuclides on SRSG getting from RESRAD using summation formula [2,6] the results summarized in Table (4).

$$\sum_{r=1}^{R} \frac{C_r}{DCGL_r} \leq 1$$

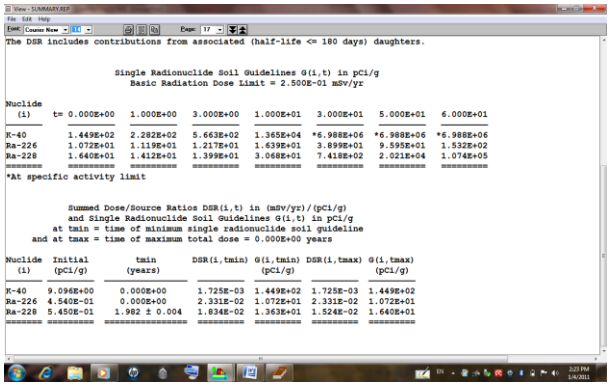
Where C=Radionuclide's concentration

DCGL= guideline value for each individual radionuclide (1, 2, ..., R)

Table(4)

Represented Sum of fraction from samples selection.

Sample Code	*Sum of Fraction*
IP-15	0.138
IP-79	1.576
IP-139	8.465
IP-182	16.23
IP-184	16.79



The DSR includes contributions from associated (half-life <= 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E-01 mSv/yr

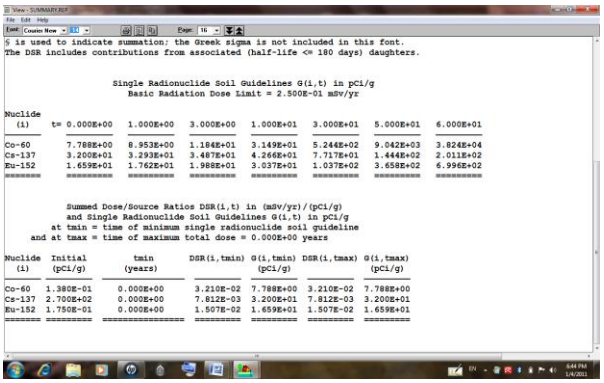
Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	5.000E+01	6.000E+01
K-40	1.449E+02	2.282E+02	5.663E+02	1.365E+04	*6.988E+06	*6.988E+06	*6.988E+06
Ra-226	1.072E+01	1.119E+01	1.217E+01	1.639E+01	3.899E+01	9.595E+01	1.532E+02
Ra-228	1.640E+01	1.412E+01	1.399E+01	3.068E+01	7.418E+02	2.021E+04	1.074E+05

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mSv/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
K-40	9.096E+00	0.000E+00	1.725E-03	1.449E+02	1.725E-03	1.449E+02
Ra-226	4.540E-01	0.000E+00	2.331E-02	1.072E+01	2.331E-02	1.072E+01
Ra-228	5.450E-01	1.982 ± 0.004	1.834E-02	1.363E+01	1.524E-02	1.640E+01

Fig. (1) Indicated Single Radionuclide Soil Sample for sample name (IP-15).



$ is used to indicate summation; the Greek sigma is not included in this font.
The DSR includes contributions from associated (half-life <= 180 days) daughters.

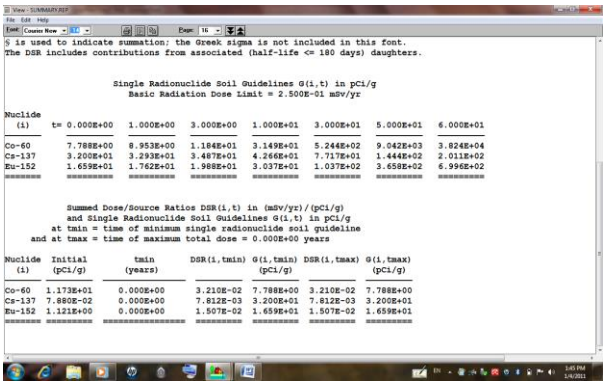
Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E-01 mSv/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	5.000E+01	6.000E+01
Co-60	7.788E+00	8.953E+00	1.184E+01	3.149E+01	5.244E+02	9.042E+03	3.824E+04
Cs-137	3.200E+01	3.293E+01	3.487E+01	4.266E+01	7.717E+01	1.444E+02	2.011E+02
Eu-152	1.659E+01	1.762E+01	1.988E+01	3.037E+01	1.037E+02	3.658E+02	6.996E+02

Summed Dose/Source Ratios DSR(i,t) in (mSv/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Co-60	1.380E-01	0.000E+00	3.210E-02	7.788E+00	3.210E-02	7.788E+00
Cs-137	2.700E+02	0.000E+00	7.812E-03	3.200E+01	7.812E-03	3.200E+01
Eu-152	1.750E-01	0.000E+00	1.507E-02	1.659E+01	1.507E-02	1.659E+01

Fig. (3) Indicated Single Radionuclide Soil Sample for sample (IP-79).



$ is used to indicate summation; the Greek sigma is not included in this font.
The DSR includes contributions from associated (half-life <= 180 days) daughters.

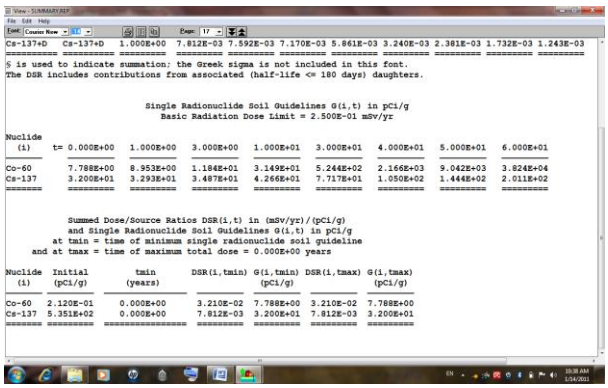
Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E-01 mSv/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	5.000E+01	6.000E+01
Co-60	7.788E+00	8.953E+00	1.184E+01	3.149E+01	5.244E+02	9.042E+03	3.824E+04
Cs-137	3.200E+01	3.293E+01	3.487E+01	4.266E+01	7.717E+01	1.444E+02	2.011E+02
Eu-152	1.659E+01	1.762E+01	1.988E+01	3.037E+01	1.037E+02	3.658E+02	6.996E+02

Summed Dose/Source Ratios DSR(i,t) in (mSv/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Co-60	1.173E+01	0.000E+00	3.210E-02	7.788E+00	3.210E-02	7.788E+00
Cs-137	7.880E-02	0.000E+00	7.812E-03	3.200E+01	7.812E-03	3.200E+01
Eu-152	1.121E+00	0.000E+00	1.507E-02	1.659E+01	1.507E-02	1.659E+01

Fig. (5) Indicated Single Radionuclide Soil Sample for sample name (IP-139).



Cs-137+D Cs-137+D 1.000E+00 7.812E-03 7.592E-03 7.170E-03 5.861E-03 3.240E-03 2.381E-03 1.732E-03 1.243E-03

S is used to indicate summation; the Greek sigma is not included in this font.
The DSR includes contributions from associated (half-life <= 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E-01 mSv/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	4.000E+01	5.000E+01	6.000E+01
Co-60	7.788E+00	8.953E+00	1.184E+01	3.149E+01	5.244E+02	2.166E+03	9.042E+03	3.824E+04
Cs-137	3.200E+01	3.293E+01	3.487E+01	4.266E+01	7.717E+01	1.050E+02	1.444E+02	2.011E+02

Summed Dose/Source Ratios DSR(i,t) in (mSv/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Co-60	2.120E-01	0.000E+00	3.210E-02	7.788E+00	3.210E-02	7.788E+00
Cs-137	5.351E+02	0.000E+00	7.812E-03	3.200E+01	7.812E-03	3.200E+01

Fig.(7) Indicated Single Radionuclide Soil Sample for sample (IP-184).

Conclusion

1. By using RESRAD software package for radionuclides found in samples (IP-79, IP-139, IP-182 and IP-184) (Table 3) the TEDE received by an individual exceed the regulatory dose limit (0.25 mSv/y) adopted by NRC, accordingly these cells need more remediation and decontamination to protect the wokers and environment from unnucessary radiation exposure.
2. The TEDE (Table 3) obtained for the radionuclides sample (IP- 15) is below the basic dose limit adopted by NRC.
3. Using RESRAD for all pathways summed, Figures (2,4,6 and 8) for radionuclide's samples (IP-15, IP-79, IP-139, and IP-184) indicated that the probability of workers that might be affected by cancer are (2.5/100.000),(20/100,000), (300/100,000), and (600/100,000) respectively.
4. The Sum of Fraction calculated using equation (1) indicated that: radionuclides sample (IP-15) equal 0.138 and it satisfy equation(1) which incur worker to TEDE equal to (0.138*0.25=0.0345 mSv/y) which it comply with release criteria.
5. Radionuclides samples (IP-79, IP-139,IP-182 and IP-184) equal 1.576 ,8.465, 16.23 and 16.79 respectively (greater than one) which it incur workers to TEDE equal to 1.576*0.25=0.394, 8.465*0.25=2.116, 16.23*0.25=4.05 and 16.79*0.25=4.18 mSv/y respectively and these are not comply with the release criteria use.
6. Comparison achieved for samples (IP-79, IP-139, IP-182 and IP-184) shown that those radionuclides found are greater than basic dose limit adopt by NRC (0.25 mSv/y) guideline.
7. To minimize the exposure to the workers we recommended to remove contamination at IPRL cell's number (IP-79, 139,182, and 184). Contamination at IPRL cell's number (IP-79, 139,182, and 184).

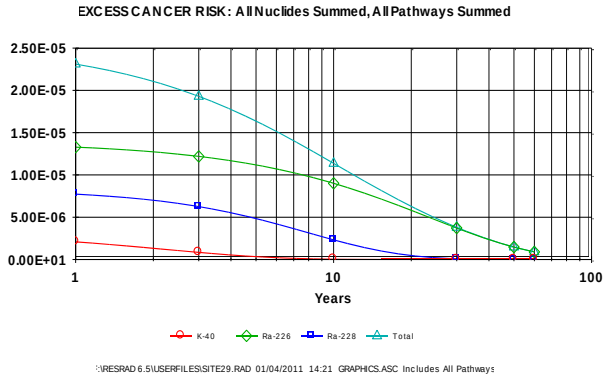


Fig.(2) Indicated probability of cancer effected from sample (IP-15).

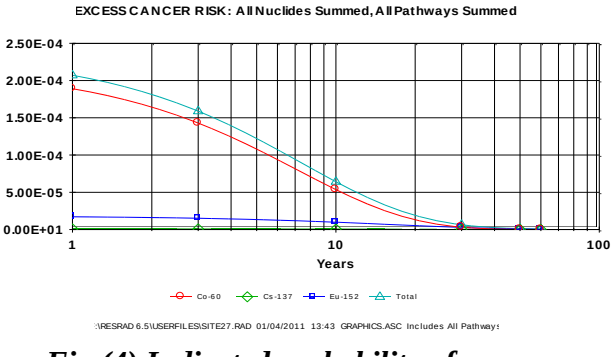


Fig.(4) Indicated probability of cancer effected from sample (IP-79).

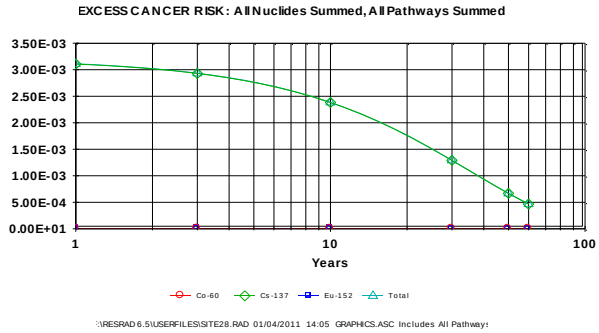


Fig.(6) Indicated probability of cancer effected from sample (IP-139).

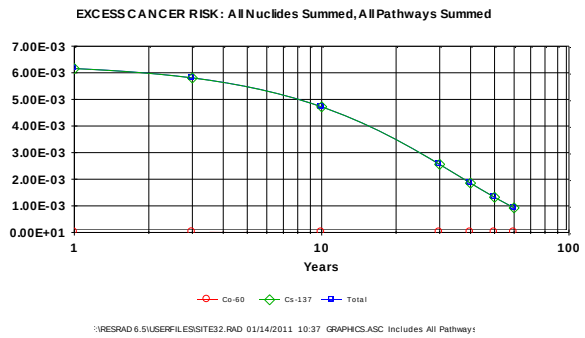


Fig. (8) Indicated probability of cancer effected from sample (IP – 184).

Reference

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الخلاصة

انجزت دراسة تخمين الجرعة السنوية واحتمالية تعرض العاملين الى جرع اشعاعية عالية في مختبرات انتاج النظائر المشعة (انتاج ايطالي) في العراق، حيث أنجزت القياسات بتصنيف منطقة الدراسة الى مربعات وجمع نماذج تربة و تحليلها باستخدام منظومة أطياف أشعة كاما (HPGe) واستخدم برنامج (RESRAD- 6.5) لتخمين الجرعة السنوية المستلمة واحتمالية الاصابة بالسرطان نتيجة تعرض العاملين للاشعاعات الصادرة من المواد المشعة المنتشرة في التربة. أظهرت النتائج بان الجرعة المكافئة الكلية المؤثرة (TEDE) المستلمة كانت من النويدات ذات المنشأ الصناعي والموجوده في الخلايا (IP-139) (2.116mSv/y) وللخلية (IP-79) (mSv/y 0.394) و للخلية (IP-184) هي (10.97mSv/y) حيث تسبب هذه الخلايا تعرض العاملين الى جرع اشعاعية سنوية اعلى من الجرعة الاشعاعية التي توصي بها هيئة الرقابة النووية الامريكية NRC (Nuclear Regulatory Commission) (0.25mSv/y) وكذلك التي توصي بها الوكالة الدولية للطاقة الذرية (IAEA) (0.3mSv/y)، في حين قدرت الجرعة المكافئة الكلية المؤثرة (TEDE) من النويدات ذات المنشآ الطبيعي في النموذج (IP-15) بحدود (0.03459 mSv/y) وهي أدنى من المستويات التي توصي بها التعليمات الدولية وعليه فان الاخلايا المذكورة اعلاه بحاجة الى معالجة لازالة التلوث و الحفاظ على سلامة العاملين والبيئة واطلاق الموقع.