Study of Contamination Soil in LAMA Facility at Al-Tuwaitha Site

Fouzey H. kitah
Dr.Yousif M. Zayir AL-BAKHAT
Amer Abdulabbas Sakran
Decommissioning Center of Destroyed Nuclear Facilities (IDC)
Ministry of Science and Technology (MoST)

Abstract

This work presents a study of radioactivity levels in the soil of LAMA (Active Metallurgy Testing Laboratory) facility after remediation activities. For this purpose, twenty two samples were gathered and analyzed by gamma spectroscopy to quantify radioactivity concentrations of radionuclides using a high-purity germanium detector and spectroscopy system. The absorbed dose rate in air (ADRA) and the annual effective dose (AED) were calculated for the radionuclides according to the guidelines of (UNSCEAR 2000). External hazard index (H_{ex}) for assessment of the radiation hazard of this facility performs according to (Beretka and Mathew) which is below unity. The results obtained were found to be within the allowable limit of 1mSv per year for public exposure recommended.

Key words: Absorbed Dose Rate in Air, Annual Effective Dose, External Hazard Index, Gamma Spectroscopy

Introduction

LAMA facility is a part of the nuclear complex which was built by France, located at the Tuwaitha site 30 Km south of Baghdad [1]. It consists of five facilities. The previous owner of facility was the Iraqi Atomic Energy Commission (IAEC). The present owner is Ministry of Science and Technology (MoST). LAMA facility is one of the Iraqi destroyed Nuclear Facilities. LAMA building was heavily attacked by bombs and rockets during the war (1991). This facility has been chosen to be the first facility decommissioning within the Iraqi Decommissioning Center (IDC). LAMA decommissioning project was designed to be a multi-stage project to clean up the LAMA Facility.

The aim of study

The aim of this study is to define and determining the levels of activity concentrations of radionuclides in LAMA soil at Al-Tuwaitha site and ascertain the dose that may accrue to those working it is comply with criteria adopted.

Material and Methods

Twenty two samples were collected from LAMA facility with their

coordinate taking by (GPS) to a depth of (5-10) cm , remove all foreign particles (stone, leaf, wood…….etc) crushed into powder by grinding machine sieved through a (0.9) mm mesh sieve, then dried in an oven at (80 – 100)^{0}C for 12 hours. Weight one kilogram and packed in marinelli beaker, closed and tightly sealed using parafilm and keep for four weeks to allow U-238 and Th-232 decay series to reach radioactive equilibrium with it short live progeny. The gamma spectrometer (Canberra) used for performance this work which consists of a detector, preamplifier and pluse-height analyzer (DSA 2000),lead shield, using vertical high purity germanium (HpGe) detector of efficiency 40 %, and resolution (2.0 keV) , normally based on the measurement of 1.332 MeV gamma ray photo peak of Co-60 source and Cooled with liquid nitrogen .Multichannel analyzer (MCA) with 8192 channel is 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. Shield has walls 10 cm lead, thick lined inside with graded absorber of Cd ~ 1.6 mm Cu ~ 0.4 mm [2,3].

Calibration and efficiency of the system are carried out using multi – gamma ray standard source (MGS-5, Canberra) of Marinelli beaker geometry. A library of radionuclides which contained the energy of the characteristic gamma emissions of each nuclide was analyzed and their corresponding emission probabilities was built from the data supplied in the software.. The concentration activity of Ra-226 was evaluated from the gamma ray 609 keV of Bi-214 peak, while 911 keV gamma line of Ac-228 or 238.6 keV of Bi-212 indicated for Th-232, k-40 activity was determined from peak at 1460.8 keV and Cs-137 was determined from gamma line 661.6 keV peak. Data on activity concentration of radionuclides (Bq.kg^{-1}) (assuming secular equilibrium between Ra-226 and their progenies) ,The activity concentrations of radioactivity of Ra-226 , Th-232 and k-40 in soil sample are given in table (1).

The absorbed dose rate in air ADRA(nGy.h^{-1}) 1m above ground level due to concentration of radionuclides presents are calculated using the formula (1) [3,4].

$$\text{ADRA (nGy.h}^{-1}) = 0.427C_{Ra-226} + 0.662\ C_{Th-232} + 0.043C_{k-40} + 0.03C_{Cs-137} \quad \text{……..(1)}$$

Where 0.427, 0.662, 0.043 and 0.03 absorbed dose in air per concentration of radionuclide (nGy.h^{-1} per Bq.kg^{-1}) for Ra-226, Th-232, K-40 and Cs-137 respectively [4] . Using results of ADRA from equation (1), the total annual effective Dose (AED in mSv.y^{-1}) can be estimated took into account the conversion coefficient, (0.7 Sv.Gy^{-1}) from the absorbed dose in air to effective dose and the occupancy factor 0.2(take into account that the people spend 20% of their time outdoor) using the formula (2) [5,6].

$$\text{AED (mSv.y}^{-1}) = \text{ADRA x24 h x 365 days x0.2 x0.7 x10}^{-6} \quad \text{……..……(2)}$$

External hazard index was calculated according to the formula (3) [7,8], the value must be less than (1 $mSv.y^{-1}$) as recommended for member of public by the European Commission on Radiation Protection Report and ICRP. [9,10]

$$H_{ex}= \frac{C_{Ra}}{370}+\frac{C_{Th}}{259}+\frac{C_k}{4810} \quad \text{……..……(3)}$$

Where C_{Ra}, C_{Th} and C_k radionuclide's concentration of Radium-226, Thorium-232 and Potassium - 40 respectively, (370, 259, 4810) Bq/kg is considered as the upper limit of(Ra, Th and k) that produce the same gamma dose equivalent [11,12].

Results and Discussion

The average radioactivity concentrations results of soil samples from LAMA facility for radionuclides ,Ra-226 (U-238 series), Ac-228) Th-232 series), k-40 and Cs-137 are (18.35) , (16.51), (322.47) and (3.38) $Bq.kg^{-1}$ respectively as in Table(1),which considered below the world average results for the same radionuclides (U-238), Th-232 series) and Cs-137, as ((25) $Bq.kg^{-1}$ while for k-40 is (400) $Bq.kg^{-1}$) [6].

From table (2) the results indicated that, the average outdoor air absorbed dose rates at 1m above ground level which are calculated according to the formula (2) are (32.69) $nGy.h^{-1}$, are considered lower than the world average (55) $nGy.h^{-1}$ [6].

The average annual effective dose rate computed according to the formula (2) is (0.42) $mSv.y^{-1}$ which is lower than the world wide average annual effective dose (1 $mSv.y^{-1}$) for public as recommended by IAEA [13, 14].

The average value of external hazard index (0.178) which are below a unity, as recommended by ICRP 2000 [10, 11].

Conclusion

According to the results of this study, LAMA facility is considered uncontaminated after remediation activities and the average annual effective dose for workers and public are below the limit which recommend by IAEA as 1 mSv per year [10, 14].

Table (1) LAMA Soil Sample activity Concentrations in $Bq.kg^{-1}$

No	Sample name	^{238}U-Series	^{232}Th-Series	Others		GPS	
		Ra-226 (BI-214)	Th-232 (Ac-228)	K-40	Cs-137	Lat	Long
1	LS-13	14.71± 0.99	14.16±1.0	288.15±14.12	1.71± 0.31	33.20242	44.51846
2	LS-15	16.94± 1.1	16.83± 0.99	344.35±15.6	1.98± 0.5	33.20266	44.51853
3	LS-17	19.87± 1.3	15.87±1.66	298.3±15.6	9.8± 0.66	33.20272	44.51883
4	LS-18	21.9± 1.45	24.5±1.76	429.4±19.2	10.5± 0.86	33.20282	44.51904
5	LS-22	20.4± 1.1	18.4±1	328.4±14.67	1.87± 0.3	33.20294	44.5193
6	LS-23	16± 1.2	17.6±1.8	360.4±17.8	3.89± 0.5	33.2021	44.5195
7	LS-26	12.4±0.81	11.7±0.85	204.3±10.7	2.19± 0.3	33.20204	44.51922
8	LS-27	28.5±1.6	16.4±1.6	376.5±17.7	3.67± 0.64	33.20234	44.51929
9	LS-28	21.5±1.2	20.2±1.1	383.4±16.8	3.5± 0.24	33.20245	44.51818
10	LS-29	18.6±1.1	18.26±1.16	394±17.7	6.4± 0.58	33.20202	44.51951
11	LS-30	17.2±1.1	15.5±1.2	323.6±14.5	1.47± 0.27	33.20311	44.51968
12	LS-31	22.75±1.16	22±1.18	362±16	2.76± 0.89	33.20264	44.51978
13	LS-33	21.66±1.07	20.76±1.03	342.9±14.4	3.26± 0.39	33.20253	44.52013
14	LS-37	18.1±0.99	14.6± 0.89	334.2±14.5	1.89± 0.87	33.20211	44.51865
15	LS-35	17.67±1.66	14.14± 0.97	320.7±15.6	2.76± 0.77	33.20198	44.52072
16	LS-20	16.4±0.79	17.4± 0.92	305.7±1.97	1.9± 0.66	33.2026	44.51931
17	LS-39	18.5±1.23	16.7±1.16	344.6±16.6	2.8± 0.43	33.20152	44.51981
18	LS-12	21.2±1.06	18.7± 0.99	366.2±15.2	1.13± 0.25	33.2022	44.51857
19	LS-40	12.8±0.65	10.12±1.15	220.4±10.37	4.11± 0.33	33.20152	44.51981
20	LS-41	11.01±0.61	9.37± 0.61	224.3±10.4	1.88± 0.24	33.20152	44.51981
21	LS-43	17.5±0.82	16.12± 0.74	221.75±13.9	3.45± 0.63	33.20142	44.51924
22	LS-44	18.1±0.81	13.97± 0.74	320.8±14.8	1.35± 0.2	33.20175	44.51937
Average		18.35	16.51	322.47	3.38		

Table (2) Represented ADRA, AED, and External Hazard Index For LAMA Soil Samples

No.	Sample name	Adsorbed Dose Rate in Air ($nGy.h^{-1}$)	Annual Effective Dose ($mSv.y^{-1}$)	H_{ex}
1	LS-13	28.06	0.034	0.154
2	LS-15	33.21	0.04	0.182
3	LS-17	32.08	0.039	0.177
4	LS-18	44.3	0.054	0.216
5	LS-22	35.03	0.043	0.194
6	LS-23	34.06	0.042	0.186
7	LS-26	21.87	0.027	0.121
8	LS-27	39.29	0.048	0.218
9	LS-28	39.1	0.048	0.216
10	LS-29	37.12	0.046	0.203
11	LS-30	31.53	0.038	0.174
12	LS-31	39.88	0.049	0.221
13	LS-33	37.79	0.046	0.209
14	LS-37	31.79	0.039	0.174
15	LS-35	30.75	0.038	0.169
16	LS-20	31.69	0.039	0.175
17	LS-39	33.8	0.041	0.186
18	LS-12	37.17	0.046	0.206
19	LS-40	21.75	0.07	0.119
20	LS-41	20.58	0.025	0.112
21	LS-43	27.75	0.034	0.156
22	LS-44	30.78	0.038	0.169

Average	32.69	0.42	0.178<1

References:-

1. Safety Report of France Complex at AL-Tuwaitha Site, 1974
2. W.J.Price ‘ Nuclear Radiation Detection’,2nd .ed.London,1964.
3. F. Adams and R.Dams ‘ Applied Gamma Ray Spectrometry’ 2nd .ed. progamon press,1970,USA.
4. Beck,H.L.,J.A.De Campo and C.V. Gogolak,1972.Insitu Ge(Li) and NaI(Tl) gamma –ray spectrometry. USAEC Report HASL-258.
5. UNSCEAR,2000.United Nation Scientific Committee on the Effects of Atomic Radiation” sources effects and risks of ionization radiation” report to the general assembly AnnxB.
6. N.N.Jibiri and G.O.Adewuyi, “ Radionuclide contents and physic-chemical characterization of solid waste and effluent samples of some selected industries in the city of Loges,Nigeria” Radioprotection, 43(2)(2008).
7. UNSCEAR,1988, Sources, effects and risks of ionization radiation. United Nation Scientific Committee on the effects of atomic radiation. Report to the general Assembly on the Effects of Atomic Radiation, United Nation, New York.
8. Berethka J.Mathew PJ (1985),Natural radioactivity of Australian Building Material, Industry wastes and bu –products. Health Physics (48);87-95.
9. K.N.YU,Z.J. Guan, M.J. Stokes, E.C.M.YOUNG, Journal of Environmental Radioactivity 17(1992)31.
10. European Commission on Radiation Protection Radiological Protection Principles Concerning the Natural Radioactivity of Building Material. European Commission Brussels Report , 1999 No.112
11. ICRP (2000),protection of the public in situations of prolonged radiation exposure, ICRP publication 82;Ann, ICRP 29(1-2).
12. YU.KN,GUAN ZJ, Stocks MJ,Young EC.The assessment of Natural Radiation Dose Committed to the Hong Kong People. Environ. Radioactivity.1992;17:31,48.
13 .Stranden, E., 1976. Some aspect on radioactivity of building material, phys. Norvegica,(8)3:167.
14 .IAEA,’ International Basic Safety Standards for Protection Against Ionizing Radiation and for Safety of Radiation Sources’ Safety Series, No.115, Vienna,1996.

دراسة تلوث تربة منشآت لاما – موقع التويثة – العراق

*فوزي حسن كاطع ، د. يوسف محسن زاير البخات وعامر عبد العباس سكران

*وزارة العلوم والتكنولوجيا – العراق / بغداد

مركز تصفية النشأت النووية المدمرة في العراق

الخلاصة

تظهر الدراسة الحالية مستويات النشاط الاشعاعي لتربة منشآت لاما احدى منشآت موقع التويثة في العراق بعد عمليات ازالة التلوث عنها ، ومن اجل انجاز هذه الدراسة تم جمع (22) نموذج وقيست باستخدام منظومة قياس اطياف كاما (كاشف الجرمانيوم عالي النقاوة) حيث تم تحديد تراكيز النويدات المنتشرة وحساب الجرعة الممتصة المتسببه عنها اضافة الى الجرعة السنوية المؤثرة ، كما جرى تخمين خطورة اشعة كاما من خلال حساب عامل الخطورة الخارجي . اظهرت الدراسه با ن الجرعة السنوية المؤثرة وعامل الخطورة اقل مما توصي به المنظمات الدولية (1 ملي سيفرت في السنة) وهي ضمن الحدود المسموح بها او المقبولة.