International Journal of Clinical Oncology and Cancer Research
2017; 2(5): 99-105
http://www.sciencepublishinggroup.com/j/ijcocr
doi: 10.11648/j.ijcocr.20170205.11

Radiological Risk Assessment for French Silo at Al-Tuwaitha Nuclear Research Site

AL-Jasim Ali Kareem, Al-Draisawi Abbas Neamah, Al-Tameemi Nabeel Hashim

Nuclear Safety Department, Ministry of Science & Technology, Baghdad, Iraq

Email address:
alieinsteingh@yahoo.com (AL-Jasim A. K.)

To cite this article:
AL-Jasim Ali Kareem, Al-Draisawi Abbas Neamah, Al-Tameemi Nabeel Hashim. Radiological Risk Assessment for French Silo at Al-Tuwaitha Nuclear Research Site. *International Journal of Clinical Oncology and Cancer Research*. Vol. 2, No. 5, 2017, pp. 99-105. doi: 10.11648/j.ijcocr.20170205.11

Received: July 8, 2017; **Accepted**: July 21, 2017; **Published**: September 7, 2017

Abstract: The French silo is located at AL-Tuwaitha nuclear research site, it is intended for temporary storage of the radioactive waste with low half-life and low or medium radioactivity. The annual doses are calculated for workers in the silo and also the risk to injury with fated cancer. The concept of a source-related dose constraint was first introduced in International Commission on Radiological Protection (ICPR) publication 60. The idea was to provide a number that individual exposures from a single, specific source should not exceed, and below which optimization of protection should take place. Dose constraints were applied to occupational and public exposures from practices. The points survey (76 points inside the silo and 31 points outside the silo) were measured using the RadEye PRD device for 3 heights (0, 1 and 3m) for each point and the adoption of the height of 1 meter because it is the effective dose on the human. The highest annual dose rate inside the silo was obtained (33.41 mSv/y) at point (9,30) and the doses mean for all points was (2.0653mSv/y) within the range (0.06_33.41), and the highest reading for the risk to injury with cancer was (1.67E-3) at same point and the rate was (1E-4) within range (1.67E-3_17E-6), also the highest annual dose rate outside the silo was obtained (17.45 mSv/y) at point (25, 45) and the doses mean for all points was (0.867mSv/y) within the range (0.035-17.45), and the heights reading for the risk to injury with cancer was (9E-4) at same point and the rate was (4.34E-05) within range (1.73E-6_9E-4).

Keywords: Safety Assessment, Risk Assessment, Radiological Risk

1. Introduction

The safety case is the collection of scientific, technical, administrative and managerial arguments and evidence in support of the safety of a waste management facility or activity, covering the suitability of the site and location and the design, construction and operation of the facility, the assessment of radiation risks and assurance of the adequacy and quality of all of the safety related work associated with the facility or activity [1, 2, 3].

Safety assessment, an integral and important part of the safety case, is driven by a systematic assessment of radiation hazards. The latter involves quantification of radiation dose and radiation risks that may arise from the facility or activity for comparison with dose and risk criteria, and provides an understanding of the behavior of the facility or activity under normal conditions and anticipated operational occurrences and in the event of accidents [1, 3, 4].

The safety case and supporting safety assessment provide the basis for demonstration of safety and for licensing. They will evolve with the development of the facility or activity, and will assist and guide decisions on siting, location, design and operations [1, 2, 4].

Waste management facilities and activities are varied in nature, size and complexity, and have different hazards associated with them, both from normal operation and from accidents. The magnitude and content of the radioactive inventory is also varied. Furthermore, a waste management facility or activity could be one of several facilities or activities on a site and may be independent of the other facilities, may be connected to other facilities or may be an integral part of a larger facility. Commensurately, the extent and complexity of the safety case and supporting safety assessment will differ according to the facility or activity, and will evolve through its lifetime (e.g. construction, commissioning, and operation). In view of these considerations, a graded approach is required to be applied to the development and review of the safety case and supporting safety assessment [5, 6].

The radioactive waste in Iraq comes from two major origins, the first one is the legacy waste which in turns comes from unidentified treated radioactive waste from contaminated wreckages and debris resulted from the second Gulf War in 1991, the second is the waste expected from the decommissioning of the destroyed nuclear buildings and facilities. Additionally, there are moderate quantities radioactive waste that comes from other activities in the universities, researches, agriculture and medical applications. NORM is recently found in considerable quantities in the oil industry. The total amounts of radioactive waste apart from NORM are more than (1050 tons) of solid waste and around (350 m^3) liquid wastes. In addition, there are more than 90 disused sealed radioactive sources (DSRS) that has to be considered as radioactive waste.

The estimated quantities of solid waste are about (105 tone) and liquid about (156 m^3) radioactive waste [7, 8, 9].

2. Objective

Calculation the received radiation doses inside and outside the silo, and also the radiation safety and risk assessment for the workers and the public (for the nearest residential area from the silo).

3. The French Silo's Description & Its Specification

The French silo located in Al-Tuwaitha nuclear research site, 20 km south of Baghdad established in 1980 to store the radioactive waste for temporary storage purposes to the radioactive waste containers and drums to protect it from the effects of rain and sunlight (shown in figure 1) [9, 10].

The silo was designed with (50 m length, 25 m width and 10 m height) and a floor of concrete, also has two gates with a width of (4.5 m), the silo is designed according to the following specifications:

a. Storage capacity (3000 drums), including concrete containers.
b. The temperature inside the silo should not exceed (60°C).
c. The height is (10 m) to ensure get air flow rate is about (14000 m^3/h)
d. Convection currents are used to dispose of gases which produced as a result of decay of stored elements.
e. The gate allows passage of a vehicle to transport the drums and containers.
f. The silo has two cranes at height of 8 m and a load of (10 tons).

Figure 1. *The French silo at AL-Tuwaitha research nuclear site.*

According to the silo design, the radioactive waste that we intended to store it is:

1. A radioactive waste with very short Half-life and a low or medium radiation level, and the purpose of storing these radioactive waste is to decay until they have very low radiation levels.
2. A treated radioactive wastes until the appropriate decision is taken to disposal them.
3. A Pre-treatment radioactive waste until the appropriate decision is taken to treat them and then return it to the silo.

The silo was damaged as a result of military actions and the destruction of many facilities at AL-Tuwaitha nuclear research site, some of these damages are falling and damaging the roof panels (falling thermal insulation of the roof), also there are some contaminated areas in the floor of the silo as a result of the damage of some of the waste drums and the leakage of their contents as in figure 2.

Figure 2. *Damaged The silo as a result of military actions.*

Therefore, the silo was rehabilitated as in figure 3, and stored as follow:

a Maintenance of damaged ceiling and lining it with thermal insulation.
b Decontamination in some ground areas.
c Add fans to pull the air out of the silo.
d Re-contain dilapidated and damaged drums as in figure 4.
e Other actions in accordance with international rules.

Figure 3. *Rehabilitated the silo.*

4. Materials & Method

4.1. Equipment & Materials

RadEye PRD (Alarming personal radiation detector, Thermo Scientific, Germany) was used in the field for monitoring gamma radiation dose rates.

RadEye PRD (shown in Figure 5) is a highly sensitive device used to measure gamma radiation in terms of counts per second (cps), ambient equivalent dose rate in microsevert per hour (μSv/h) and the accumulated ambient equivalent dose (in μSv). The RadEye PRD incorporates a highly sensitive NaI (TI) scintillation detector which is equipped with a miniature photomultiplier allowing detection of very low radiation levels. The detection for gamma radiation dose rate range from 0.01 μSv/h to 250 μSv/h. The selection of RadEye PRD over other available radiation detector is primarily based on the RadEye PRD's ability to detect low-energy gamma radiation, which comprises the majority of the gamma radiation from the radionuclides of concern in the studied areas [11].

Figure 4. *Re-contain dilapidated drums.*

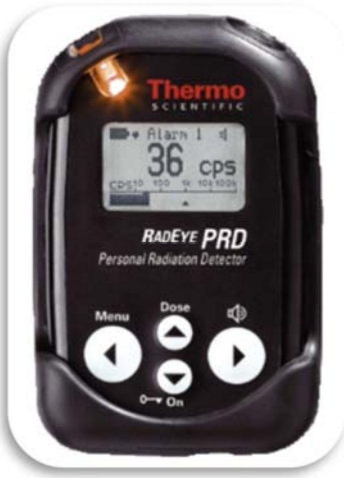

Figure 5. *Rad Eye PRD device.*

4.2. Experimental Method

The silo was divided to grids with area (1 m^2) inside and outside the silo. The received dose is measured at 3 height (0, 1 and 3m) respectively for each point, it were (76 points) inside the silo and (31 points) outside the silo and these points are represented by (x, y) axes. The readings were adopted to calculate the received dose and risk rates inside and outside the silo at (1 m) height for each point because it is the effective dose on the human.

5. Results

5.1. Calculation the Rate of the Received Dose

At point (3.0) on 1 m height inside the silo

a Dose received = 0.23 μSv/h * 1 h * 10^{-3}
= $23*10^{-5}$ mSv/h

b By assumed the worker works (3 hour/day) with (4 day/week)
Number of working hours per the year = 3 h/d * 4 d/w * 4 w/m * 12 m/y
= 576 h/y

c Rate of dose received per the year = $23*10^{-5}$ mSv/h * 576 h/y
= 0.13248 mSv/y

5.2. Risk Calculation

At point (3.1) on 1 m height inside the silo
Risk for one person = dose rate * number of year * risk factor
= 0.13248 mSv/y * 1 y * 0.05 Sv^{-1} *10^{-3}
= $6.6*10^{-6}$
** Risk factor to injury with fated cancer = 0.05 Sv^{-1} [12].

Table 1. *Calculation of the received dose and the risk inside the silo.*

	Position	Dose Rate at (0m) µSv/h	Dose Rate at (1m) µSv/h	Dose Rate at (3m) µSv/h	Dose Rate at (1m) mSv/y	Risk
1	(3,0)	0.22	0.23	0.18	0.13248	6.62E-06
2	(3,10)	0.19	0.18	0.2	0.10368	5.18E-06
3	(3,15)	0.21	0.23	0.18	0.13248	6.62E-06
4	(3,20)	0.2	0.25	0.23	0.144	7.2E-06
5	(3,25)	30	16	4	9.216	4.6E-4
6	(3,30)	1.5	0.52	0.38	0.29952	1.5E-05
7	(3,35)	0.42	0.51	0.65	0.29376	1.47E-05
8	(3,40)	0.34	0.18	0.6	0.10368	5.18E-06
9	(3,45)	0.3	0.18	0.2	0.10368	5.18E-06
10	(3,50)	0.25	0.2	0.23	0.1152	5.76E-06
11	(6,0)	0.4	0.33	0.35	0.19008	9.5E-06
12	(6,5)	0.34	0.51	0.49	0.29376	1.47E-05
13	(6,10)	0.45	0.35	0.35	0.2016	1.01E-05
14	(6,15)	1.5	1.53	1.2	0.88128	4.41E-05
15	(6,20)	0.57	0.29	0.47	0.16704	8.35E-06
16	(6,25)	0.35	0.43	0.62	0.24768	1.24E-05
17	(6,30)	3.8	3	2.8	1.728	8.64E-05
18	(6,35)	0.67	1.3	1.12	0.7488	3.74E-05
19	(6,40)	0.59	0.7	0.84	0.4032	2.02E-05
20	(6,45)	1	0.85	0.74	0.4896	2.45E-05
21	(6,50)	0.43	0.35	0.38	0.2016	1.01E-05
22	(9,0)	0.1	0.13	0.09	0.07488	3.74E-06
23	(9,5)	0.17	0.11	0.14	0.06336	3.17E-06
24	(9,10)	0.17	0.32	0.29	0.18432	9.22E-06
25	(9,15)	2	1.9	1.8	1.0944	5.47E-05
26	(9,20)	1.5	0.68	0.6	0.39168	1.96E-05
27	(9,25)	4	4.9	13	2.8224	1.4E-4
28	(9,30)	6.7	58	8	33.408	1.67E-3
29	(9,35)	7.9	42	7.3	24.192	1.21E-3
30	(9,40)	30	6.7	5.3	3.8592	1.93E-4
31	(9,45)	4.6	0.75	0.6	0.432	2.16E-05
32	(9,50)	3	2.8	2	1.6128	8.06E-05
33	(12,0)	0.1	0.13	0.17	0.07488	3.74E-06
34	(12,5)	0.22	0.32	0.4	0.18432	9.22E-06
35	(12,10)	1.18	1.44	1.2	0.82944	4.15E-05
36	(12,15)	2.5	5.5	5.6	3.168	1.58E-4
37	(12,20)	2.9	3.3	3.2	1.9008	9.5E-05
38	(12,25)	3	3.1	3.3	1.7856	8.93E-05
39	(12,30)	3.6	3	2.5	1.728	8.64E-05
40	(12,35)	3.2	8.4	4.47	4.8384	2.42E-4
41	(12,40)	4.7	4.2	3.3	2.4192	1.21E-4
42	(12,45)	3.4	2.8	2.4	1.6128	8.06E-05
43	(12,50)	1.1	0.74	0.99	0.42624	2.13E-05
44	(15,0)	0.26	0.33	0.3	0.19008	9.5E-06
45	(15,5)	0.25	0.33	0.35	0.19008	9.5E-06
46	(15,10)	1.77	3	1.84	1.728	8.64E-05
47	(15,15)	1.54	3.1	4.5	1.7856	8.93E-05
48	(15,20)	0.54	1.5	0.54	0.864	4.32E-05
49	(15,25)	2.2	1.35	2.1	0.7776	3.89E-05
50	(15,30)	3.4	3.09	3.4	1.77984	8.9E-05
51	(15,35)	3.4	2.9	3.6	1.6704	8.35E-05

	Position	Dose Rate at (0m) µSv/h	Dose Rate at (1m) µSv/h	Dose Rate at (3m) µSv/h	Dose Rate at (1m) mSv/y	Risk
52	(15,40)	3.6	2.8	2.4	1.6128	8.06E-05
53	(15,45)	2.9	2.4	2.36	1.3824	6.91E-05
54	(15,50)	0.5	0.37	1.4	0.21312	1.07E-05
55	(19,0)	0.72	0.5	0.35	0.288	1.44E-05
56	(19,5)	0.4	0.37	0.4	0.21312	1.07E-05
57	(19,10)	0.39	0.28	0.2	0.16128	8.06E-06
58	(19,15)	0.42	0.2	1.18	0.1152	5.76E-06
59	(19,20)	0.2	1.15	0.9	0.6624	3.31E-05
60	(19,25)	1.35	1.85	2.23	1.0656	5.33E-05
61	(19,30)	4.12	5.65	4.25	3.2544	1.63E-04
62	(19,35)	2.88	3.15	4.35	1.8144	9.07E-05
63	(19,40)	2.6	2.32	3.45	1.33632	6.68E-05
64	(19,45)	11.4	8.5	5	4.896	2.45E-04
65	(19,50)	3.26	3.3	2.8	1.9008	9.5E-05
66	(23,0)	6.43	1.7	4.66	0.9792	4.9E-05
67	(23,5)	0.7	1	3.23	0.576	2.88E-05
68	(23,10)	0.54	0.5	0.58	0.288	1.44E-05
69	(23,15)	0.55	0.55	0.55	0.3168	1.58E-05
70	(23,20)	8.7	6.2	1.6	3.5712	1.79E-04
71	(23,25)	6.04	5.2	2.61	2.9952	1.5E-04
72	(23,30)	6.25	3.55	3.72	2.0448	1.02E-04
73	(23,35)	2.11	5.13	3.64	2.95488	1.48E-04
74	(23,40)	11.6	12.5	7	7.2	3.6E-04
75	(23,45)	3.62	5	3.5	2.88	1.44E-04
76	(23,50)	2.2	3.4	2.8	1.9584	9.79E-05
	Min				0.063	3.2E-06
	Max				33.408	1.67E-3
	Average				2.0653	1E-4

Table 2. *Calculation of the received dose and the risk outside the silo.*

	Position	Dose Rate at (0m) µSv/h	Dose Rate at (1m) µSv/h	Dose Rate at (3m) µSv/h	Dose Rate at (1m) mSv/y	Risk
1	(0,0)	0.05	0.07	0.11	0.04032	2.02E-06
2	(0,5)	0.07	0.06	0.08	0.03456	1.73E-06
3	(0,10)	0.14	0.07	0.08	0.04032	2.02E-06
4	(0,15)	0.08	0.1	0.13	0.0576	2.88E-06
5	(0,20)	0.14	0.15	0.1	0.0864	4.32E-06
6	(0,25)	0.11	0.09	0.09	0.05184	2.59E-06
7	(0,30)	0.13	0.24	0.16	0.13824	6.91E-06
8	(0,35)	0.18	0.11	0.14	0.06336	3.17E-06
9	(0,40)	0.29	0.22	0.25	0.12672	6.34E-06
10	(0,45)	0.32	0.33	0.6	0.19008	9.5E-06
11	(0,50)	0.68	0.33	0.38	0.19008	9.5E-06
12	(5,50)	0.2	0.14	0.44	0.08064	4.03E-06
13	(10,50)	0.42	0.37	0.22	0.21312	1.07E-05
14	(15,50)	1.3	1.2	2.6	0.6912	3.46E-05
15	(20,50)	0.9	0.73	1.2	0.42048	2.1E-05
16	(25,50)	0.55	1.2	2.2	0.6912	3.46E-05
17	(25,45)	47.3	30.3	10.9	17.4528	8.73E-04
18	(25,40)	0.9	2.3	3.4	1.3248	6.62E-05
19	(25,35)	0.54	1.2	0.95	0.6912	3.46E-05
20	(25,30)	0.53	0.34	0.5	0.19584	9.79E-06
21	(25,25)	0.87	0.4	0.35	0.2304	1.15E-05
22	(25,20)	0.45	0.45	0.44	0.2592	1.3E-05
23	(25,15)	0.45	0.47	0.7	0.27072	1.35E-05
24	(25,10)	0.43	0.6	0.82	0.3456	1.73E-05
25	(25,5)	0.45	0.6	0.93	0.3456	1.73E-05
26	(25,0)	0.5	0.58	0.76	0.33408	1.67E-05
27	(20,0)	1.4	1.55	2.5	0.8928	4.46E-05
28	(15,0)	1.13	1.7	1.3	0.9792	4.9E-05
29	(10,0)	0.28	0.5	0.35	0.288	1.44E-05
30	(5,0)	0.26	0.21	0.2	0.12096	6.05E-06
31	(0,0)	0.05	0.07	0.11	0.04032	2.02E-06
	Min				0.03456	1.72E-06
	Max				17.4528	8.73E-04
	Average				0.867	4.34E-05

6. Discussion & Conclusion

The total annual dose limit and approved by the International Commission on Radiological Protection (ICRP) for each year is (20 mSv), as is known, the workers in AL-Tuwaitha nuclear research site are assigned to work in more than one radiation facility like (French silo, Tammuz-2 reactor, radio isotopes protection laboratories, LAMA facility, etc.) Therefore, the total effective dose received from all these facilities should not exceed (20 mSv/y), it is unacceptable to allow the worker to take (20 mSv/y) from each facility, that is mean (20 mSv/y) is the dose limit for the worker at all AL-Tuwaitha nuclear research site.

ICRP recommendations determine the dose for a worker in such conditions at one-quarter of the dose limit it is called (Dose Constraint). This means that the dose limit for the worker in the French silo during the whole year is (5 mSv/y) [13, 14, 15].

6.1. Inside the Silo

6.1.1. Effective Dose

The highest reading of the received dose inside the silo is (33.408 mSv/y), It is a high reading and be effective on the human body when compared it with the restricted limits of the workers (5 mSv/y), but the probability of worker exposure at this point is very low, and it is unacceptable that the worker remains at this point, especially for long periods, but if we compare the dose rate received inside the silo (2.065 mSv/y), It is within the doses limits (5 mSv/y) in these conditions.

6.1.2. Risk

The highest level of risk is (1.67E-3), It is a very high reading when compared it with the international limits permitted and approved by the World Health Organization (WHO) which is equal to (10^{-4}-10^{-6}), but the probability of worker exposure at this point is very low and it is unacceptable that the worker remains at this point, especially for long periods, the rate of risk is equal to (10^{-4}), It is within the international restrictions permitted (10^{-4}).

6.2. Outside the Silo

6.2.1. Effective Dose

The highest reading of the dose received outside the silo is (17.4528 mSv/y), It is a high reading and be effective on the human body when compared it with the restricted limits for the workers (5 mSv/y), but the probability of worker exposure at this point is very low, and it is unacceptable that the worker remains at this point, especially for long periods, and warning signs must be placed at this point, but if we compare the dose rate received outside the silo (0.867 mSv/y) are within the doses limits (5 mSv/y) in these conditions.

6.2.2. Risk

The highest level of risk is (8.73E-04), It is a very high reading when compared it with the international limits permitted and approved by the World Health Organization (WHO) which is equal to (10^{-4}-10^{-6}), and it's with risk level unacceptable, but the probability of worker exposure at this point is very low, it is unacceptable to stay the working at this point, especially for long periods.

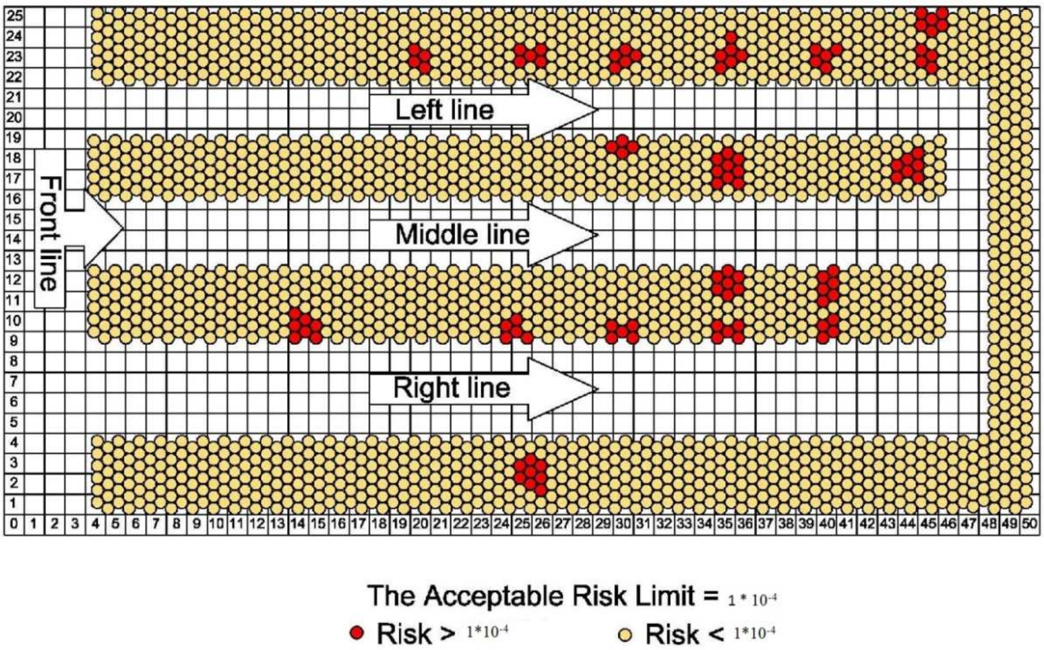

Figure 6. *Shows the distribution of points above & below the dose limits.*

The rate of risk is equal to (4.34E-05), It is within the international limits permitted (10^{-4}).

There is no radiation effect on the general public and it is attributed to two reasons:

a The nearest residential area (Ishtar and ALTaamem) is about (1-1.5km) distance from for the silo French.
b The presence of earthy berm between silo and residential area.

Based on the safety procedures, the drums containing high radioactive waste should be distributed in different places inside the silo to distribute the high doses so reduce the risk for the workers, also alarm sings should be put to describe the safety procedures to be followed at high risk points.

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5, IAEA, Vienna (2009).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna (2009).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Series No. 115, international basic safety standards for protection against ionizing radiation and for the safety of radiation sources, IAEA, Vienna (1996).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Report Series No.19, Generic models for use in assessing the impact of discharges radioactive substances to the environment, IAEA, Vienna (2001).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Series No. 111-F, The Principles of Radioactive Waste Management, IAEA, Vienna (1995).

[6] NTERNATIONAL ATOMIC ENERGY AGENCY, Safety Series No. 111-G-1.1, Classification of Radioactive Waste, IAEA, Vienna (1994).

[7] Al-Musawi, F., Shamsaldin, E. S. and Cochran, J. R., 2011, Radioactive Waste Management Challenges and Progress in Iraq," Proceedings of the ASME 2011 14th International Conference on Environmental Remediation and Radioactive Waste Management ICEM2011, Reims, France.

[8] Dennis, M. L., Shamsaldin, E. S. and Cochran, J. R., 2011, Iraq Liquid Radioactive Waste Tanks Maintenance and Monitoring Program Plan, SAND2011-6549, Sandia National Laboratories, Albuquerque, NM.

[9] http://www-ns.iaea.org/projects/iraq/tuwaitha.asp?s=8&l=66.

[10] http://www-ns.iaea.org/projects/iraq/sites-overview.asp?s=8&l=66.

[11] Thermo scientific, Manual of Alarming Personal Radiation Detector, Rad Eye PRD, DB_057-050322 E.

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Specific Safety Requirements No. SSR-5, Disposal of Radioactive Waste, IAEA, Vienna (2011).

[13] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, The 2007 Recommendations of the International Commission on Radiological Protection, Publication 103, Pergamon Press, ICRP, Oxford and New York (2007).

[14] Dr. Ann Mc Garry, Dose Constraints in Occupational Radiation Protection, Regulations and Practices, Radiological Protection Institute of Ireland Chair.

[15] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Publication 60, 1990 Recommendations of the International Commission on Radiological Protection, Annals ICRP 21 (1-3): 1-201, 1991.