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Risk assessment for retrieving legacy radioactive waste in Al-Tuwaitha site

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ABSTRACT

The large quantities of radioactive waste (RW) in Iraq are of different origins. Some of the waste was produced in the former Iraqi Atomic Energy Commission IAEC –Nuclear Research Centre (NRC) activities in the fields of (physics, chemistry, medicine, agricultural and other nuclear activities) which certainly produce radioactive waste. The waste were properly collected, packed and disposed in a special concrete facility so called the Russian Silo, which was built in the early sixties of the last century. This facility is still intact and contains radioactive waste of the sixties, seventies and eighties. The log book and all documents of the radioactive waste were lost in the successive wars and looting in the 2003 events. The management of the radioactive waste is basically depends upon the inventory of the RW which in turns depends upon the proper classification of the RW, and accordingly the type of treatment and the end point of the RW (i.e. the type of disposal facility)will be decided. RW in the Russian silo were covered and it is very difficult to quantify or qualify by external measurements because of the heavy concrete shielding of the facility. The Russian Silo was re-equipped with 5 ton bridge crane to enable the removal of the concert plugs (covers)of the wells. For radiation protection purposes the wells were numbered and a dose map at the top and the sides of the facility were drawn. The radiation dose rate for each well were measured before and after the removal of the concrete plugs, each well were identified for the radionuclide that is contaminating the waste, it has been used a very sophisticated, well advanced hand held HPGe detector with an efficiency 42% produced by ORTEC to obtain more reliable and accurate results for the risk assessment calculations. More than 95% of the concrete wells were an uncovered. It was noted the following:-
1-Most of RW are either combustible or compressible.
2-The most predominant contaminant is Cs-137, Co-60 and Pa-234.
3-Some of the well constituent were measured and identified and the concentration levels were around 5.04×10^{4}Bg /kg.
4-The end point of the RW were identified as near surface disposal facility

Keywords: Risk assessment, radioactive waste, classification, annual limit on intake (ALI).

INTRODUCTION

Radioactive waste is hazardous to most forms of life and the environment, and is regulated by government agencies in order to protect human health and the environment[1].The large quantities of radioactive waste (RW) in Iraq are of different origins. The legacy RWwhich was produced in the former Iraqi Atomic Energy Commission IAEC –Nuclear Research Centre (NRC) laboratories in the fields of (physics, chemistry, agricultural and other nuclear activities) are certainly produce radioactive waste. The waste were collected, packed in metal barrels and stored in the storage bunker, some other waste were collected in plastic sacks anddisposed in a special vertical wells in a concrete facility called the Russian Silo which was built in the early sixties of the last century Russian Silo (old Russiancemetery) is a building similar the silo,it was designed for store low radioactive waste and are equipped with Crane 2 ton to raise the slots wells. The dimensions of the building from the outside are 60m × 10m × 4m. This silo is located at Al-Tuwaitha site, a nuclear research center 18 km south of Baghdad. Russian silo is still intact and contains radioactive waste of the sixties, seventies and eighties. There is no information about the stored waste in both facilities as the log books and all documents of the radioactive waste were lost in the successive wars and theaccompaniedevents.

The key factor for the management of radioactive waste is the inventory of the waste which means that classification and characterization of the waste has to be identified. Classification will help in identifying the degree of hazard of the waste while characterization will help in the handling, treatment and identification of the end point of the waste[2].It was planned that all legacy radioactive waste has to be properly managed classified,characterized, treated and conditioned to prepare it for the final disposal. This means that all the RW in RS has to be properly retrieved and managed.

The plan of the retrieval of the legacy waste from the RS will need the classification and characterization of the RW as a first crucial step to identify all kinds of risks, technical, skill and fund requirements.

Current guidelines are based on the conservative assumption that there is no safe level of exposure. In other words, even the smallest exposure has some probability of causing a stochastic effect, such as cancer. This assumption has led to the general philosophy of not only keeping exposures below recommended levels or regulation limits but also maintaining all exposure "as low as reasonable achievable" (ALARA). ALARA is a basic requirement of current radiation safety practices. It means that every reasonable effort must be made to keep the dose to the public as far below the required limits as possible.Radioactive waste classification systems have been developed to enable wastes having similar hazards to be grouped for purposes of storage, treatment, packaging, transportation, and/or disposal. As recommended in the National Council on Radiation Protection and Measurements' Report No. 139[3]. Radioactive Waste Treatment and Management, Ministry of Science and Technology published documents regarding standardization orclassification of radioactive waste as shown in Table 1.

Table I:Iraqi radioactive waste system classification adopted from IAEA [4]

Waste class	Properties	Disposal options
Exempt waste	Activity below clearance levels based on annual dose to members of critical groups of less than 10µSv	No restrictions
Low and intermediate level waste	Activity higher than class 1 negligible thermal power2 kW/m^3	Near surface or deep underground disposal facility
Short lived	Content of long lived radionuclides restricted by the regularity authority on the basis of safety considerations	Geological disposal (near surface disposal in greater confinement disposal facilities may be possible for specific types and amounts of long lived waste)
Long lived	Content of long lived radionuclides above limits for short lives waste	
High level waste and spent fuel (if declared waste)	Content of long lived radionuclides above limits for short lives waste High thermal power above 2 kW/m^3	Deep underground disposal facility

In this research, this method has been adopted for the classification of radioactive waste and then developed to include risks to human whose work in the field of radiation as a result of taking by inhalation. The new classification depends on the annuallimit on intake (ALI)calculations of workers in the radiation and compared these values with the allowed values. ALI is the is defined as the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose calculated by the International Commission on Radiological Protection (ICRP) [5]. On the other hand, radiotoxicity is a measure of how harmful a radionuclide is to worker health when inhaled. Radiotoxicity depends on the type and energy of the radiation emitted and the radionuclide’s biochemical behavior in the human body. The harm that can be done depends on the dose of radiation received. The paper illustrates a new proposal or approach to classify the waste for near surface disposal. The new approach is based on to what extent the radionuclide element hazard for human according to its ALI value.Boundary levels between classes are presented as orders of magnitude and typicalcharacteristics of waste classes [6].

MATERIALS AND METHODS

The primary purposes of the safety assessment are to determine whether an adequate level of safety has been achieved for a facility or activity and whether the basic safety objectives and safety criteria established by the designer, the operator and the regulatory body have been fulfilled.

For a disposal facility, safety assessment entails evaluating the performance of the disposal system and quantifying its potential radiological impact on human health and the environment. Safety assessment is one component of the safety case for a disposal facility and should consider the possible radiological impacts of the facility both during its operation and in the post-closure phase. Radiological impacts may arise from gradual processes which may cause the facility and its components (e.g. barriers) to degrade, and from discrete events that may affect the isolation of the waste (e.g. earthquakes, tsunamis, floods, fire, inadvertent human intrusion)[7]

To determine the safety assessment, the ALI must be calculated by Eq 1.The unit for the Annual on Intake is the Becquerel (Bq).

$$ALI = \frac{D_{AL}}{h} \qquad (1)$$

where
D_{AL} is the annual dose limit for the effective dose, and

h is Dose Conversion Factors (DCFs) provided by the International Atomic Energy Agency (IAEA) in its Safety Series 115 document[8,9], these factors give the dose per unit intake by inhalation or ingestion for a large number of radionuclides, for adults and children of various ages. They are thus useful for calculating committed doses for workers, who might experience intakes in the workplace, as well as individuals or populations near nuclear sites, where intakes might occur due to offsite releases of radionuclides.

The equivalent dose $H_{T,R}$ in tissue or organ T is obtained by multiplying the average absorbed dose $D_{T,R}$ in the tissue or organ by a radiation weighting factor W_R *Eq 2*,[10]

$$H_{T,R} = D_{T,R} \times W_{T,R} \qquad (2)$$

where
$D_{T,R}$ is the average absorbed dose in tissue or organ *T* caused by radiation quality *R*, and.

W_R is the radiation weighting factor for radiation quality *R*,

If the radiation is composed of several radiation qualities with different W_R values, the equivalent dose H_T is calculated by Eq 3:

$$H_T = \sum_R D_{T,R} \times W_R \qquad (3)$$

The effective dose D_{AL} is the sum of the equivalent doses H_T, multiplied by the tissue weighting factors W_T is calculated by Eqs. 4 and 5:

$$D_{AL} = \sum_T H_T \times W_T \qquad (4)$$

$$D_{AL} = \sum_T W_T \sum_R D_{T,R} \times W_R \qquad (5)$$

The unit of effective dose is the Sievert

Activity concentrations using gamma-ray spectrometer and distributions of natural radionuclides in Russian silo are investigated to assess the environmental radioactivity and characterization of radiological hazard to workers. A gamma spectrometer and relevant accessories were supplied by Canberra, USA.

In this research the Russian silo was re-equipped with 5 ton bridge crane to enable the removal of the well covers(concert plugs) of the silo. The wells were numbered and a dose map for the top and the sides of the facility were drawn. The radiation dose rate for each well were measured before and after the removal of the concrete plugs, each well were identified for the radionuclide that is contaminating the waste, it has been used a very sophisticated, well advanced piece of equipment produced by ORTEC hand held HPGe detector with an overall efficiency (better than 42%). More than 95% of the concrete wells were auncovered. The resolution of this detector is 1.32185KeV for Co-60 energy.The energy calibration of HPGe gamma-ray spectrometer is performed by Co-60 radioactive source as shown in Fig.1

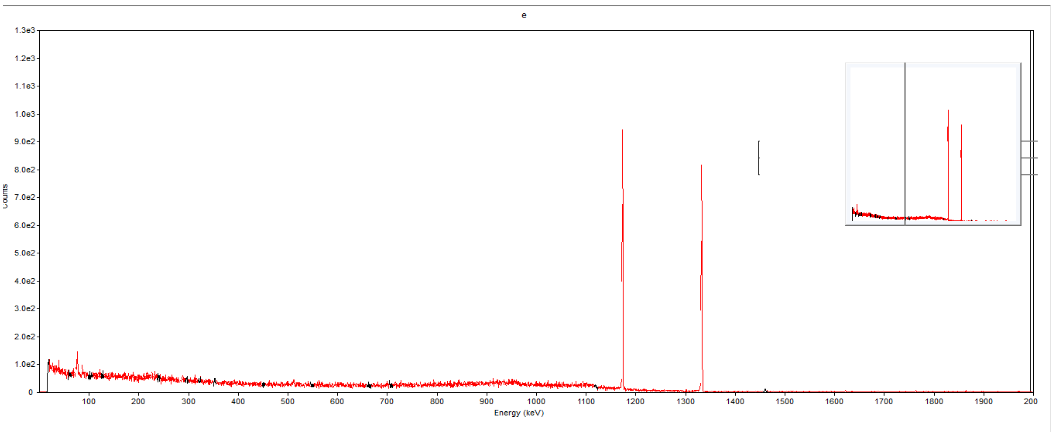


Figure 1: Calibration spectrum for HPGe detector using Co-60

The samples spectra are corrected for background radiation, the background values obtained by using Eq. (6)

$$\text{Background (Bq)} = \frac{Area}{IY\%\ EFF\ \%\ Tc} \quad (6)$$

where

Area: The net area under the peakcount

I_Y %: The branching ratio for photon energy

Eff: Efficiency of the HPGe detector.

Tc:The total counting time interval in seconds

The specific activity for samplesare measured by Eq.7

$$\text{Specific Activity(Bq)} = \frac{(Area - Bg)/Tc}{IY\%\ Eff\ \%\ m} \quad (7)$$

m=the mass of samples

RESULTS AND DISCUSSION

Table 2 shows the well numbers, types, energy,half-lives and dose of radionuclides for workers. Then by using Eq.5 the annual effective dose are obtained. Finally the ALI values are obtained by using Eq. 1.

The present work has shown an approach to classify the waste. The new approach is based on to what extent the radionuclide element hazard for workers according to it's our calculated of ALI values of radionuclide element. The lower value is the higher hazardous element. TheICRP has defined the ALI for all radionuclide elements for inhalation cases. The present study according to the limit cited in Table 3 ranking the radionuclide elements into 7 classes, externally high hazard EHH, very high hazard VHH, high hazard HH, intermediate hazard IH, low hazard LH, VLH and extremely low hazard ELH. This classification is not considered either the half-life or activity, only the harmful effect of radionuclide is the concern factor. Each class has various radionuclides with wide range of half-life. No common factor is appeared in each class.Figure 2 represents theclassification of radioactive elements according to our calculated of ALI values for radionuclides in disposal silo.

Table 2: The well numbers, types, gamma emitted energy, halve-live, effective dose, our calculated of ALI, and ALI for radionuclides in the silo

Wells no	Type of radionuclide's	Energy in KeV	Activity in Bq	Half life	Annual Effective of radionuclide in μSv/y	Conversion factor μSv/Bq	Our calculated of ALI in Bq	ALI in Bq
1.1	Th-234	92.8	18619.21	24.1 d	0.149321	5.30E-03	28.1739	9433962.2
	Ra-226	186.1	12909.84	1.60E+03	0.207625	2.2	0.09438	22727.27
	Cs-137	661.66	701.89	30.07 y	0.040134	6.70E-03	5.99021	7462686.5
	Pa-234M	1001.03	27088.84	6.70 h	2.343422	5.50E-04	4260.77	90909090.9
	Co-60	1173.24	17246.52	5.2714 y	1.748643	7.10E-03	246.288	7042253.5
	Co-60	1332.5	18765.85	5.2714 y	2.16096	7.10E-03	304.362	7042253.5
	Bi-214	1407.98	2100.63	0.332 h	0.255598	1.20E-02	21.2999	4166666.6
	K-40	1461	609.92	1.28E+09a	0.07700	3.00E-03	25.6693	16666666.6
1.3	Th-234	92.8	16323.642	24.1 d	0.13091	5.30E-03	24.7003	9433962.264
	Ra-226	186.1	13536.33	1.60E+03	0.217700	2.2	0.09895	22727.27273
	Cs-137	661.66	1627.73	30.07 y	0.09307	6.70E-03	13.8917	7462686.567
	Pa-234M	766.36	40743.096	6.70 h	2.698359	5.50E-04	4906.11	90909090.91
	Pa-234M	1001.03	25861.562	6.70 h	2.23725	5.50E-04	4067.73	90909090.91
	Co-60	1173.24	729.66	5.2714 y	0.073981	7.10E-03	10.4199	7042253.521
	Co-60	1332.5	856.35	5.2714 y	0.09861	7.10E-03	13.8891	7042253.521
	Bi-214	1407.98	2888.29	0.332 h	0.351439	1.20E-02	29.2866	4166666.667
1.5	Pa-234M	98.44	83954.842	6.70 h	0.714217	5.50E-04	1298.58	90909090.91
	Eu-154	123.07	833.15	8.593 y)	0.008861	3.50E-02	0.25317	1428571.429
	Ra-226	186.1	3962.8313	1.60E+03	0.063733	2.2	0.02897	22727.27273
	Pb-214	241.98	2051.11	6.70 h	0.042892	4.80E-03	8.93594	10416666.67
	Co-60	346.93	8880584.4	5.2714 y	266.2541	7.10E-03	37500.6	7042253.521
	Ac-228	409.46	285.8825	6.15 h	0.010116	2.90E-02	0.34883	1724137.931
	Bi-214	609.31	435.89	0.332 h	0.022952	1.20E-02	1.9127	4166666.667
	Cs-137	661.66	25384.58	30.07 y	1.45150	6.70E-03	216.642	7462686.567
	Bi-212	785.37	30338.494	60.55 m	2.059118	1.50E-02	137.275	3333333.333
	Ac-228	964.77	6675.011	6.15 h	0.556530	2.90E-02	19.1907	1724137.931
	Bi-212	1078.62	43238.55	60.55 m	4.030441	1.50E-02	268.696	3333333.333
	Co-60	1173.24	32259.71	5.2714 y	3.270847	7.10E-03	460.683	7042253.521
	Eu-154	1274.44	407.88	8.593 y	0.044922	3.50E-02	1.2835	1428571.429
	Co-60	1332.5	34718.42	5.2714 y	3.997976	7.10E-03	563.095	7042253.521
	Bi-214	1407.98	23534.99	0.332 h	2.86367	1.20E-02	238.639	4166666.667
1.6	Pa-234M	98.44	22410.7	6.70 h	0.190651	5.50E-04	346.639	90909090.91
	Ra-226	186.1	4560.34	1.60E+03	0.073342	2.2	0.03334	22727.27273
	Co-60	346.93	1428898.2	5.2714 y	42.84066	7.10E-03	6033.9	7042253.521
	Bi-214	609.31	2830.67	0.332 h	0.14905	1.20E-02	12.4211	4166666.667
	Cs-137	661.66	2899.93	30.07 y	0.165819	6.70E-03	24.7492	7462686.567
	Eu-154	723.3	6584.76	8.593 y	0.411596	3.50E-02	11.7599	1428571.429
	Ac-228	964.77	4182.49	6.15 h)	0.348715	2.90E-02	12.0247	1724137.931
	Co-60	1173.24	31019.89	5.2714 y	3.145141	7.10E-03	442.978	7042253.521
	Co-60	1332.5	32577.74	5.2714 y	3.751467	7.10E-03	528.376	7042253.521
	Bi-214	1407.98	11228.72	0.332 h	1.366280	1.20E-02	113.857	4166666.667
2.1	Th-234	92.8	201.67	24.1 d	0.001617	5.30E-03	0.30516	9433962.264
	Ra-226	186.1	754.39	1.60E+03	0.01213	2.2	0.00551	22727.27273
	Cs-137	661.66	135.82	30.07 y	0.007766	6.70E-03	1.15914	7462686.567
	Pa-234M	1001.03	3180.71	6.70 h	0.275159	5.50E-04	500.29	90909090.91
	Sr-91	1024.3	13.41	9.63 h	0.00118	2.90E-04	4.09328	172413793.1
	Co-60	1332.5	104.96	5.2714 y	0.012086	7.10E-03	1.70234	7042253.521
2.3	Th-234	92.8	17876.34	24.1 d	0.143363	5.30E-03	27.0498	9433962.264
	Eu-154	123.07	463.18	8.593 y	0.004926	3.50E-02	0.14075	1428571.429
	Ra-226	186.1	11175.38	1.60E+03	0.179730	2.2	0.0817	22727.27273
	Co-60	346.93	3093273	5.2714 y	92.74128	7.10E-03	13062.2	7042253.521
	Cs-137	661.66	4379.64	30.07 y	0.250429	6.70E-03	37.3776	7462686.567
	Bi-212	785.37	13418.04	0.332 h	0.910702	1.50E-02	60.7135	3333333.333
	Ac-228	964.77	2441.9	6.15 h	0.203593	2.90E-02	7.02048	1724137.931
	Pa-234M	1001.03	23728.39	6.70 h	2.052713	5.50E-04	3732.21	90909090.91
	Co-60	1173.24	47856	5.2714 y	4.852173	7.10E-03	683.405	7042253.521
	Co-60	1332.5	4930.31	5.2714 y	0.56774	7.10E-03	79.9643	7042253.521
	Bi-214	1407.98	8943.96	0.332 h	1.088276	1.20E-02	90.6897	4166666.667
2.4	Pa-234M	98.44	328866.15	6.70 h	2.797717	5.50E-04	5086.76	90909090.91
	Ra-226	186.1	11010.6	1.60E+03	0.177080	2.2	0.08049	22727.27273
	Co-60	346.93	1230620	5.2714 y	36.89596	7.10E-03	5196.61	7042253.521
	Cs-137	661.66	2844.1	30.07 y	0.162627	6.70E-03	24.2727	7462686.567
	Ac-228	964.77	3859.25	6.15 h	0.321765	2.90E-02	11.0954	1724137.931
	Pa-234M	1001.03	27972.03	6.70 h	2.419825	5.50E-04	4399.68	90909090.91
	Co-60	1173.24	26832.44	5.2714 y	2.720570	7.10E-03	383.179	7042253.521
	Co-60	1332.5	24889.52	5.2714 y	2.866135	7.10E-03	403.681	7042253.521
	Bi-214	1407.98	8762.43	0.332 h	1.066188	1.20E-02	88.8491	4166666.667
	Eu-154	723.3	1381.64	8.593 y	0.086362	3.50E-02	2.46751	1428571.429
2.6	Pa-234M	98.44	253465	6.70 h	2.156267	5.50E-04	3920.49	90909090.91
	Ra-226	186.1	10927.97	1.60E+03	0.175751	2.2	0.07989	22727.27273
	Cs-137	661.66	6755.47	30.07 y	0.386281	6.70E-03	57.6539	7462686.567
	Bi-212	609.31	194.41	0.332 h	0.010236	1.50E-02	0.68246	3333333.333
	Pa-234M	1001.03	22417.43	6.70 h	1.939304	5.50E-04	3526.01	90909090.91

	Co-60	1173.24	6295.86	5.2714 y	0.638344	7.10E-03	89.9076	7042253.521
	Co-60	1332.5	19601.87	5.2714 y	2.25724	7.10E-03	317.921	7042253.521
	Bi-214	1407.98	21219.6	0.332 h	2.581943	1.20E-02	215.162	4166666.667
	Eu-154	723.3	1028.74	13.537 y	0.06430	3.50E-02	1.83725	1428571.429
3.1	Th-234	92.8	1017.21	24.1 d	0.008157	5.30E-03	1.5392	9433962.264
	Ra-226	186.1	2834.61	1.60E+03	0.045588	2.2	0.02072	22727.27273
	Cs-137	661.66	898.77	30.07 y	0.051392	6.70E-03	7.67046	7462686.567
	Bi-214	609.31	494.3	0.332 h	0.026028	1.20E-02	2.16901	4166666.667
	Pa-234M	1001.03	7081.03	6.70 h	0.612571	5.50E-04	1113.77	90909090.91
	Co-60	1173.24	616.88	5.2714 y	0.062546	7.10E-03	8.80932	7042253.521
	Co-60	1332.5	750.51	5.2714 y	0.086424	7.10E-03	12.1725	7042253.521
	Bi-214	1407.98	2912.34	0.332 h	0.354365	1.20E-02	29.5305	4166666.667
3.2	Pa-234M	98.44	8354.14	6.70 h	0.07107	5.50E-04	129.218	90909090.91
	Ra-226	186.1	1618.74	1.60E+03	0.026033	2.2	0.01183	22727.27273
	Co-60	346.93	1064063.9	5.2714 y	31.90234	7.10E-03	4493.29	7042253.521
	Cs-137	661.66	4269.71	30.07 y	0.244144	6.70E-03	36.4394	7462686.567
	Ac-228	964.77	2260.66	6.15 h	0.188482	2.90E-02	6.49941	1724137.931
	Bi-212	1078.62	14513.33	0.332 h	1.352846	1.50E-02	90.1898	3333333.333
	Co-60	1173.24	99.96	5.2714 y	0.010135	7.10E-03	1.42747	7042253.521
	Co-60	1332.5	97.89	5.2714 y	0.011272	7.10E-03	1.58767	7042253.521
	Bi-214	1407.98	8110.71	0.332 h	0.986889	1.20E-02	82.2408	4166666.667
	Eu-154	123.07	148.74	8.593 y	0.001581	3.50E-02	0.0452	1428571.429
4.1	Eu-154	123.07	925.88	8.593 y	0.009847	3.50E-02	0.28135	1428571.429
	Ra-226	186.1	6394.36	1.60E+03	0.102838	2.2	0.04674	22727.27273
	Co-60	346.93	7353529.4	5.2714 y	220.470	7.10E-03	31052.2	7042253.521
	Cs-137	661.66	98057.6	30.07 y	5.606981	6.70E-03	836.863	7462686.567
	Ac-228	964.77	8507.47	6.15 h	0.709311	2.90E-02	24.459	1724137.931
	Bi-212	1078.62	35676.4	0.332 h	3.325542	1.50E-02	221.703	3333333.333
	Co-60	1173.24	4045.21	5.2714 y	0.410148	7.10E-03	57.7674	7042253.521
	Co-60	1332.5	4275.33	5.2714 y	0.492322	7.10E-03	69.3412	7042253.521
	Bi-214	1407.98	20828	0.332 h	2.53429	1.20E-02	211.191	4166666.667
	Bi-214	609.31	833.79	0.332 h	0.043904	1.20E-02	3.6587	4166666.667
	Eu-154	723.3	1043.19	8.593 y	0.065207	3.50E-02	1.86306	1428571.429
4.2	Cs-137	661.66	3786.09	30.07 y	0.216490	6.70E-03	32.312	7462686.567
	Bi-212	893.41	1022.68	0.332 h	0.078959	1.50E-02	5.26396	3333333.333
	Ac-228	964.77	180.46	6.15 h	0.015045	2.90E-02	0.51882	1724137.931
	Co-60	1173.24	271.22	5.2714 y	0.027499	7.10E-03	3.87314	7042253.521
	Co-60	1332.5	267.12	5.2714 y	0.030760	7.10E-03	4.3324	7042253.521
	Bi-214	1407.98	696.33	0.332 h	0.084727	1.20E-02	7.06063	4166666.667
4.6	Cs-137	661.66	676.18	30.07 y	0.038664	6.70E-03	5.77079	7462686.567
	K-40	1461	145.46	1.28E+09a	0.018365	3.00E-03	6.12189	16666666.67
5.1	Cs-137	661.66	23391.59	30.07 y	1.337542	6.70E-03	199.633	7462686.567
	Co-60	1173.24	1898.4	5.2714 y	0.192480	7.10E-03	27.11	7042253.521
	Co-60	1332.5	2036.27	5.2714 y	0.234485	7.10E-03	33.0261	7042253.521
	Bi-214	1407.98	5857.25	0.332 h	0.712694	1.20E-02	59.3912	4166666.667
5.2	Pa-234M	98.44	39834.42	6.70 h	0.338877	5.50E-04	616.141	90909090.91
	Cs-137	661.66	18758.49	30.07 y	1.072619	6.70E-03	160.092	7462686.567
	Co-60	1173.24	70.89	5.2714 y	0.007187	7.10E-03	1.01234	7042253.521
	Co-60	1332.5	73.08	5.2714 y	0.008415	7.10E-03	1.18528	7042253.521
	K-40	1461	526.43	1.28E+09a	0.066466	3.00E-03	22.1556	16666666.67
6.1	Co-60	346.93	1782861.8	5.2714 y	53.45305	7.10E-03	7528.6	7042253.521
	Cs-137	661.66	11144.57	30.07 y	0.637252	6.70E-03	95.1122	7462686.567
	Co-60	1173.24	3270.35	5.2714 y	0.33158	7.10E-03	46.702	7042253.521
	Co-60	1332.5	3541.71	5.2714 y	0.40784	7.10E-03	57.4427	7042253.521
	Bi-214	609.31	397.54	0.332 h	0.020933	1.20E-02	1.74442	4166666.667
	Bi-214	1407.98	5457.95	0.332 h	0.664108	1.20E-02	55.3424	4166666.667
6.3	Cs-137	661.66	6195.9	30.07 y	0.354284	6.70E-03	52.8783	7462686.567
	Co-60	1173.24	4129.03	5.2714 y	0.41864	7.10E-03	58.9644	7042253.521
	Co-60	1332.5	4025.8	5.2714 y	0.463588	7.10E-03	65.2941	7042253.521
6.4	Ra-226	186.1	3574.89	1.60E+03	0.057493	2.2	0.02613	22727.27273
	Cs-137	661.66	717.55	30.07 y	0.041029	6.70E-03	6.12386	7462686.567
	Bi-214	609.31	36.83	0.332 h	0.001939	1.20E-02	0.16161	4166666.667
	Pa-234M	1001.03	8743.42	6.70 h	0.75638	5.50E-04	1375.24	90909090.91
	K-40	1461	535.62	1.28E+09a	0.067626	3.00E-03	22.5423	16666666.67
6.6	Pa-234M	98.44	154069.75	6.70 h	1.31069	5.50E-04	2383.08	90909090.91
	Cs-137	661.66	148.92	30.07 y	0.008515	6.70E-03	1.27094	7462686.567
	K-40	1461	175.43	1.28E+09a	0.022149	3.00E-03	7.38322	16666666.67

Table 3: Classification of radioactive wastes according to ALI values

CLASS	LIMIT
EHH	AI ≤ 0.1
VHH	AI≤ 1
HH	AI ≤ 10
IH	AI ≤ 40
LH	AI ≤ 100
VLH	AI ≤ 900
ELH	AI >900

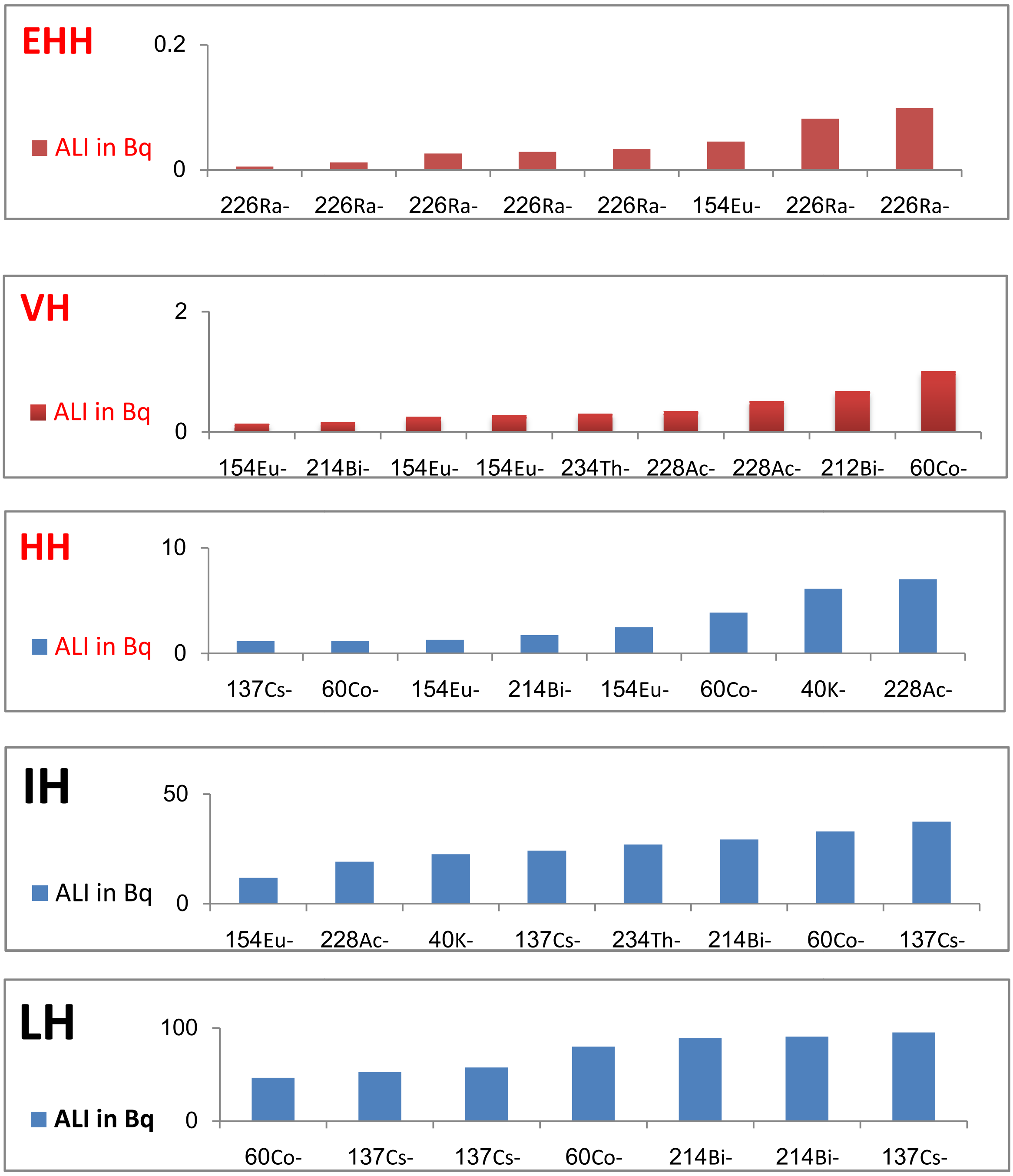
Table 4: The classification of ALI value for a hazard level

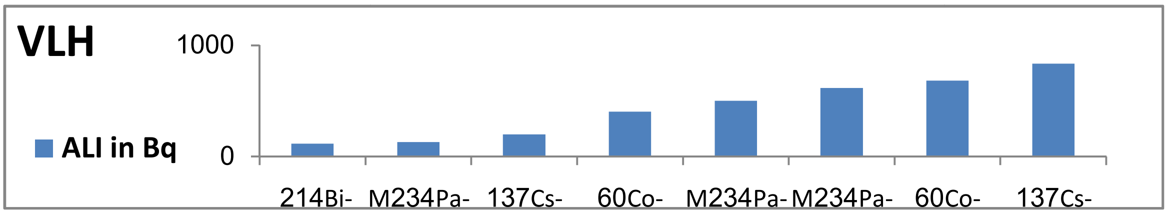
EHH				
2.1	Ra-226	0.005514836	22727.27273	2.42653E-05
3.2	Ra-226	0.011833516	22727.27273	5.20675E-05
6.4	Ra-226	0.026133609	22727.27273	0.000114988
1.5	Ra-226	0.028969587	22727.27273	0.000127466
1.6	Ra-226	0.03333757	22727.27273	0.000146685
3.2	Eu-154	0.045198597	90909090.91	4.97185E-08
2.3	Ra-226	0.081695665	22727.27273	0.000359461
1.3	Ra-226	0.098954978	22727.27273	0.000435402
VH				
2.3	Eu-154	0.140749537	1428571.429	9.85247E-06
6.4	Bi-214	0.161611328	4166666.667	3.87867E-06
1.5	Eu-154	0.253174742	1428571.429	1.77222E-05
4.1	Eu-154	0.281353214	1.43E+06	1.96947E-05
2.1	Th-234	0.305159171	9433962.264	3.23469E-06
1.5	Ac-228	0.3488302	7042253.521	4.95339E-06
4.2	Ac-228	0.518823652	7042253.521	7.3673E-06
2.6	Bi-212	0.682462304	3.33E+06	2.04739E-05
5.2	Co-60	1.012340263	90909090.91	1.11357E-06
HH				
2.1	Cs-137	1.159142488	7462686.567	1.55325E-05
5.2	Co-60	1.18527856	7042253.521	1.6831E-05
1.5	Eu-154	1.283502684	1428571.429	8.98452E-05
6.1	Bi-214	1.744419426	4166666.667	4.18661E-05
2.4	Eu-154	2.467506696	1428571.429	0.000172725
4.2	Co-60	3.873140444	3333333.333	0.000116194
4.6	K-40	6.121890617	16666666.67	3.67313E-05
2.3	Ac-228	7.020478093	4166666.667	0.000168491
IH				
1.6	Eu-154	11.7598936	1428571.429	0.000823193
1.5	Ac-228	19.19069925	4166666.667	0.000460577
6.4	K-40	22.54232815	16666666.67	0.000135254
2.4	Cs-137	24.27269291	7462686.567	0.000325254
2.3	Th-234	27.04977979	9433962.264	0.000286728
1.3	Bi-214	29.28660687	4166666.667	0.000702879
5.1	Co-60	33.02609707	7462686.567	0.00044255
2.3	Cs-137	37.37760865	7462686.567	0.00050086
LH				
6.1	Co-60	46.70203102	7042253.521	0.000663169
6.3	Cs-137	52.87830175	7462686.567	0.000708569
2.6	Cs-137	57.65389711	7462686.567	0.000772562
2.3	Co-60	79.96429582	7042253.521	0.001135493
2.4	Bi-214	88.84905693	4166666.667	0.002132377
2.3	Bi-214	90.68973005	4166666.667	0.002176554
6.1	Cs-137	95.11224121	7462686.567	0.001274504
VLH				
1.6	Bi-214	113.8566793	4166666.667	0.00273256
3.2	Pa-234M	129.2181996	90909090.91	0.00014214
5.1	Cs-137	199.633234	7462686.567	0.002675085
2.4	Co-60	403.6810951	7462686.567	0.005409327
2.1	Pa-234M	500.2896278	90909090.91	0.000550319
5.2	Pa-234M	616.141462	90909090.91	0.000677756
2.3	Co-60	683.4046498	7042253.521	0.009704346
4.1	Cs-137	836.8629838	7462686.567	0.011213964
ELH				
2.6	Pa-234M	3920.486245	90909090.91	0.004312535
3.2	Co-60	4493.287898	7042253.521	0.063804688
2.4	Pa-234M	5086.758398	90909090.91	0.005595434
2.4	Co-60	5196.614249	7042253.521	0.073791922
6.1	Co-60	7528.599908	7042253.521	0.106906119
4.1	Co-60	31052.19915	7042253.521	0.440941228
2.3	Co-60	3940230.124	7042253.521	55.95126776

Table 4 shows the well numbers, types of radionuclides, our calculated of ALI value, standard ALI value andpercentratio of our calculated / standard ALI

Fig.2 represents that the radionuclide have been classified into seven categories according to worker hazards.On the other hand, radiotoxicity is a measure of how harmful a radionuclide is to worker health when inhaled. Radiotoxicity depends on the type and energy of the radiation emitted and the radionuclide's biochemical behavior in the human body. The harm that can be done depends on the dose of radiation received.The classification system for disposal has the importance to manage the buried radionuclidesin such a way and under different circumstances (normal and accidental cases) in a safesystem. This system should not lead to any hazard to the environment. Therefore theclassification system for disposal purposes is considered the first step in the safe system.

The resulted classification is independent on the half-life or activity as it is usually considered. And only the harmful effect of radionuclide is the concern factor, the lower value is the higher hazardous element. And these values calculated for risk assessment to inhalation for workers. The summary of calculations for the hazards of the square wells is manifested in Fig.3.





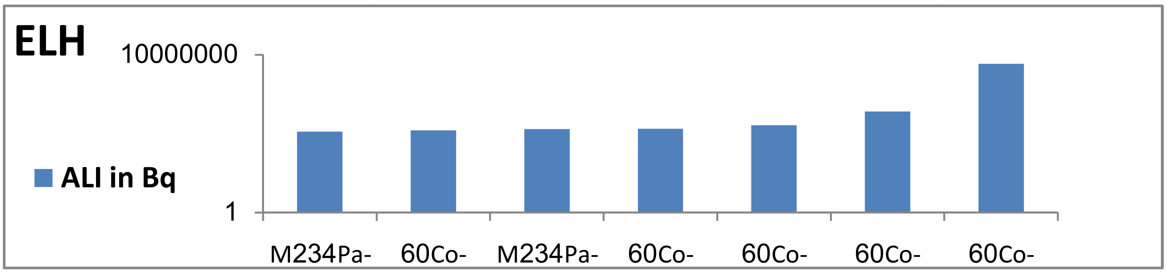


Figure 2: The classification of radioactive elements according to our calculated of ALI values for radionuclides in disposal silo

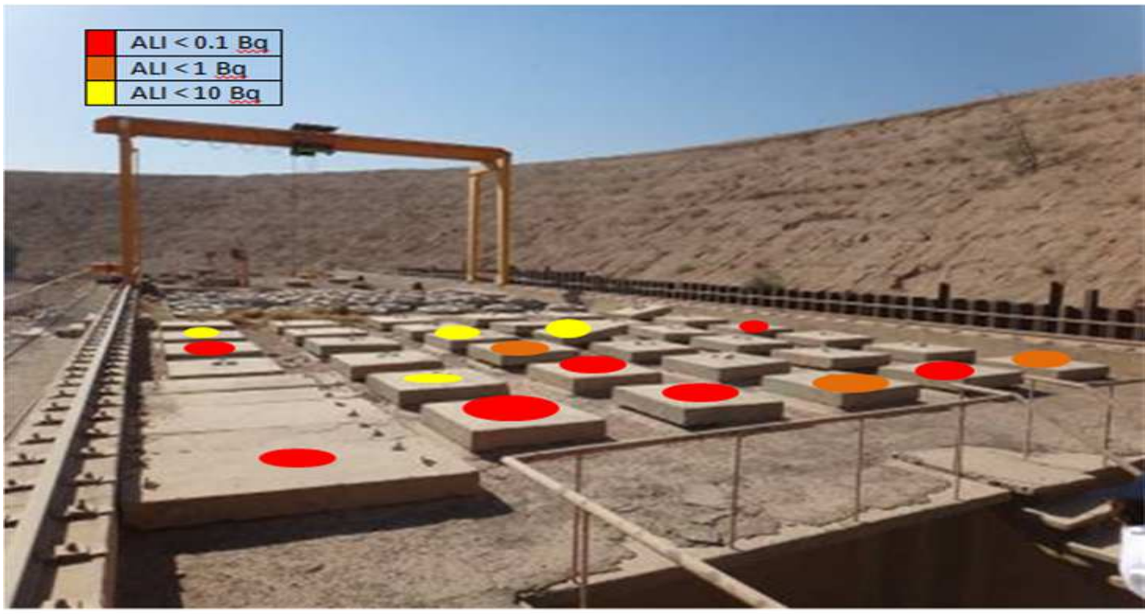


Figure 3: The hazard level for the wells

CONCLUSION

The present work try to establish a classification system for the disposal based on AI values.
1. This work is considered a primary work towards national disposal criteria in the Russian silo.
2. The classification method selected ranked the radionuclides in seven categories according to the harmful effect of radionuclides.
3. Fig. 2 shows that the EHH and VHH categories contained nuclides have very high half-life; therefore these radionuclides have been considered very hazard radionuclides.

REFERENCES

[1] International Atomic Energy Agency, Classification of radioactive waste, IAEAsafety standards, General safety Requirements, No GSR Part 5, Vienna**2009**.
[2]HussianSaadiA.Al-Daffaie, Y.K.Bind, Emad S. Shamsaldin, *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*,**2014 (**3), 11,47-54
[3] NCRP Report No. 139, Risk-Based Classification of Radioactive and Hazardous Chemical Wastes, **2002**.

[4]International Atomic Energy Agency, Categorizing Operational Radioactive WastesIAEA-TECDOC-1538, (**April 2007**),
[5] Mahmoud N.S., M.M. Abdellatif, *International Journal of Environmental Sciences*,**2011**,2 (2), 537-559.
[6] International Atomic Energy Agency, classification of radioactive waste for protecting people and the environment,IAEA Safety standards GSG-1General Safety Guide, **2009**.
[7] International Atomic Energy Agency, Classification of Radioactive Waste, IAEA Safety Series No. 111G1.1, IAEA, Vienna, **1994**.
[8]International Atomic Energy Agency, Radiation Protection and Safety of Radiation Sources: International Basic, IAEASafety Standards, Interim Edition No. GSR Part 3 (Interim) General Safety Requirements Part 3, 115(**2011**).
[9] International Commission on Radiation Protection,Compendium of Dose Coefficients based on ICRP Publication 60/ICRP, Publication 119, Elesever, (**2011**).
[10] International Commission on Radiation Units and Measurements. Measurement of Dose Equivalents from External Photon and Electron RadiationsICRU Report 47. Bethesda, MD(**1992**).