

PRELIMINARY POST CLOSURE SAFETY ASSESSMENT AND PRE-DISPOSAL RADIOMONITORING OF ANARAK NEAR SURFACE REPOSITORY

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Abstract. Anarak disposal facility is the primary low and intermediate level radioactive waste disposal site located Anarak District, in Nain County, Isfahan Province, Iran. This paper presents the Preliminary post closure safety assessment report and pre-disposal radiomonitoring of Anarak Near Surface Repository in order to determine levels and variability of radiological conditions prior to operation that is needed in the licensing process for near surface disposal repository. The Preliminary post closure safety assessment has been performed based on ISAM methodology recommended by IAEA and AMBER Code is used for simulation of each scenario. Three scenarios have been selected, including water erosion, bath-tubbing and human intrusion. The water erosion considered as a design scenario as for climate condition, types of cover and trench design. 1100 years after closure of the repository and in case of water erosion scenario the maximum total dose is less than 0.2 mSv y^{-1} for the representative person who is living near the repository. Furthermore, the maximum dose is caused by ^{241}Am that is equal to 0.15 mSv y^{-1} . All the results showed that estimated doses of radionuclides in each scenario are less than dose constraint established by Iran National Regulatory Authority. Periodically about 200 samples including foodstuff, feeding material, surface and ground water, soil and sediment, airborne particulate, radon and external radiation were gathered and analyzed. By using TLDs, The maximum average dose equivalent value measured was approximately $100 \text{ } \mu\text{Sv month}^{-1}$. Gross alpha and beta activities were measured in common food commodities, including animal products, meat, grain, vegetables and feeding materials. The ambient radon concentration in the air was found to vary from 5.55 to $18.4 \pm 0.2 \text{ Bq m}^{-3}$. The measured gamma absorbed dose rate in the air at 1 m above the ground ranged from 0.043 to 0.075 nGy h^{-1} with an overall arithmetic mean of 0.068 nGy h^{-1} . The activity concentration of anthropogenic (^{90}Sr , ^{137}Cs) and natural (^{238}U , ^{232}Th , ^{40}K) radionuclide were determined in 78 soil and sediment samples. Tritium activity, total alpha/beta and gamma-ray spectrometry analysis has been performed in all drinking water, surface and groundwater samples. In general, all results showed the background level of the natural and artificial radionuclides before any operation in Anarak near surface disposal facility.

Key Words: Anarak repository, Safety assessment scenarios, Pre-disposal, Radiomonitoring.

1. Introduction

Environmental radioactivity measurements are necessary for determining the background radiation level due to natural radioactivity sources of terrestrial and cosmic origin [1]. Pre-disposal radiomonitoring provides a baseline for comparison with environmental data during the operational phase and after decommissioning the facility. Background radiation is defined in the standard as: “radiation from cosmic sources; naturally-occurring radioactive material, including radon (except as a decay product of source or special nuclear material); and global fallout as it exists in the environment from the testing of nuclear explosive devices or from past nuclear accidents such as Chernobyl that contribute to background radiation and are not under the control of the licensee [2].

Based on the national strategy of nuclear waste management, the use of near surface repository for the land disposal of low and intermediate level radioactive waste in Iran is considered. In line with the internationally agreed principles of radioactive waste management, and the national Regulations on Radioactive Waste Management prepared by

INRA-AEOI¹, the safety of this facility needs to be ensured during all stages of its lifetime, including the post-closure period. In this direction, the radiological environmental monitoring and Preliminary Post Closure Safety Assessment is done during pre-operational period of the Anarak site. Anarak disposal facility is the primary low and intermediate level radioactive waste disposal site located Anarak city. Anarak city is situated in the central part of Iran, in Nain County, Isfahan Province. Agricultural activities are limited because of climate conditions, lack of water resources, and water quality. The area has very low rainfall. The annual precipitation rate is less than 100 mm. Annual mean evaporation rate is higher than 3000 mm. Annual prevailing wind direction is from ENE and SSE. This study aims to assess the environmental radioactivity level of the Anarak site and surrounding region prior to operation phase. In addition Preliminary Post Closure Safety Assessment is done in various scenarios to estimate doses of radionuclides in comparison with dose constrain established by Iran National Regulatory Authority. The results from this study are expected to serve as baseline data of natural radioactivity level and will be useful in assessing public doses.

2. Materials and Methods

2.1. Preliminary Post Closure Safety Assessment: Software and Scenarios

The Preliminary post closure safety assessment has been performed based on ISAM methodology recommended by IAEA and AMBER Code is used for simulation of each scenario. Three scenarios have been selected, including water erosion, bath-tubbing and human intrusion. The water erosion considered as a design scenario as for climate condition, types of cover and trench design. In this scenario the water infiltrate from upper side of the site to the trenches and dissolves 5 percent of the waste in it, passing through unsaturated zone close to the trench, exits to the surface and by temporary rivers reaches to the manmade pool next to the site. These events would repeat for other 5 percent of the waste in next year that it means 10 percent of the waste has transferred to the biosphere area. Start of this event is after end of the passive institutional control period.

2.2. Pre-Disposal Radiomonitoring: Program and Collection of Samples

Pre-disposal radiomonitoring is done by using grid and judgmental sampling patterns. Periodically about 200 samples including foodstuff, feeding material, surface and ground water, soil and sediment, airborne particulate, radon and external radiation were collected and analysed. In Table I and Table II Key radionuclides and radiomonitoring program in different media of Anarak site is shown, respectively. The nearest population centre to this facility is Anarak city with about 1500 population. The monitoring area spans an area of 5000 km². All samples were taken from various points, including: Anarak site, Anarak city, Chah-Gorbe, Ashin, Esmailan and Piyook villages and agricultural field-Dagh-e-Sorkh (*See FIG.1*).

TABLE I: KEY RADIONUCLIDES IN PRE-DISPOSAL RADIOMONITORING PROGRAM

Radiation Sources	Cosmic	Naturally-Occurring Radioactive Material	Global Fallout
Radionuclides	³ H, ⁷ Be	²³⁸ U, ²²⁶ Ra, ²³² Th, ⁴⁰ K, ²²² Rn	¹³⁷ Cs, ⁹⁰ Sr, ³ H

¹ Iran Nuclear Regulatory Authority- Atomic Energy Organization of Iran

TABLE II: PRE-DISPOSAL RADIOMONITORING PROGRAM OF ANARAK SITE

Sampling Media			Sampling Device	Sampling Type	Analysis Device	Sampling Frequency
Air	Particulates		High Volume Sampler	Judgmental	Low Level Counter	Quarterly
	Radon		RAD7		RAD7	
Direct Radiation			TLDs	Grid and Judgment	TLD Reader	Quarterly
			RS-230 GR-135		RS-230 GR-135	Annually
Soil			-	Grid and Judgmental	HPGe LSC	Annually
Sediment			-	Judgmental	HPGe LSC	Annually
Water Resources	Groundwater		-	Judgmental	HPGe LSC	Semi-annually
	Surface Water		-	Judgmental	Low Level Counter RAD7	Seasonally
Biota Samples	Foodstuff	Animal	-	Judgmental	HPGe Low Level Counter	Annually
	Vegetable					Annually
Feeding Material			-	Judgmental		Annually

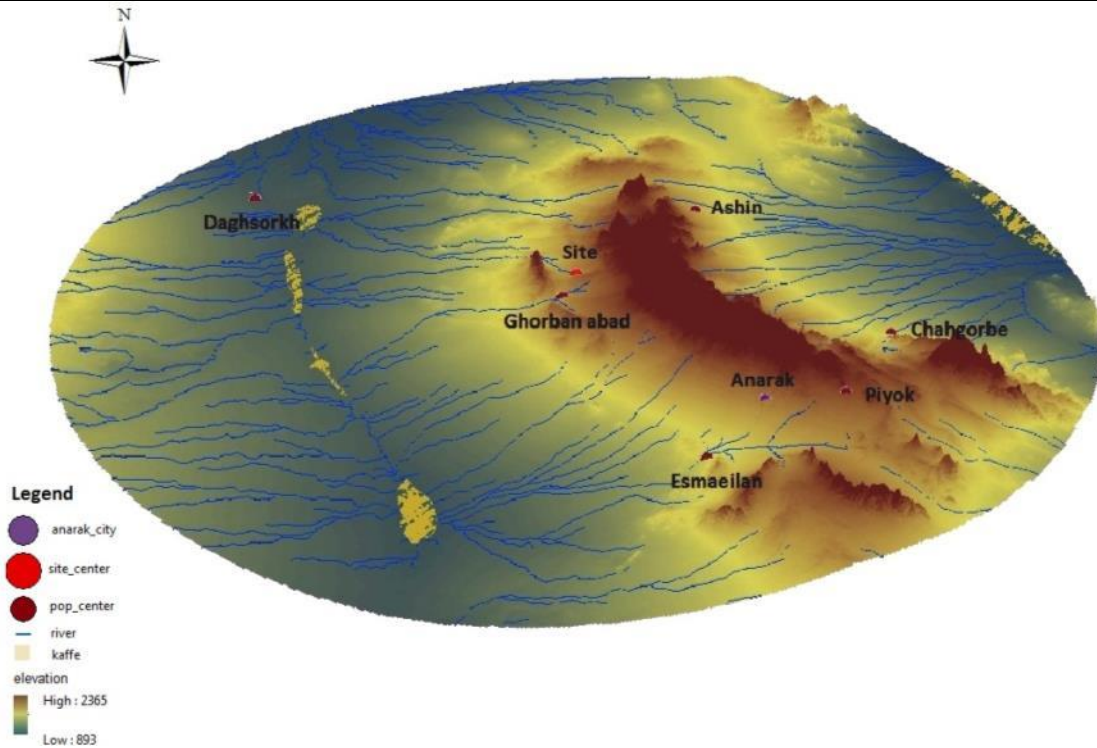


FIG. 1. Pre-disposal radiomonitoring area, population centers, Anarak site, seasonal surface water streams and the elevation of the studying zone

3. Results and Discussion

3.1. Preliminary Post Closure Safety Assessment: Results for Design Scenario

Assuming the representative person who is living near the repository, 1100 years after closure and in case of water erosion scenario the maximum total dose is less than 0.2 mSv y^{-1} . Furthermore, the maximum dose is caused by ^{241}Am that is equal to 0.15 mSv y^{-1} .

1.2. Pre-Disposal Radiomonitoring: Results for Representative Environmental Samples

Seventy-eight surface soil and sediment samples at a depth of 0–10 cm range were collected from the sampling area on grid and judgmental basis. Mean activity concentrations of ^{238}U , ^{226}Ra , ^{232}Th , ^{40}K and ^{137}Cs in the soil and sediment samples were about 34.12 ± 1.39 , 34.03 ± 0.69 , 35.14 ± 3.46 , 527.09 ± 17.72 and 5.944 ± 1.2 Bq Kg⁻¹, respectively. Two methods of active and passive were applied in order to measure external background dose rate. By using TLDs in 25 points, the maximum average dose equivalent value measured was approximately 100 $\mu\text{Sv month}^{-1}$. The measured gamma absorbed dose rate in the air at 1 m above the ground ranged from 0.043 to 0.075 nGy h⁻¹ with an overall arithmetic mean of 0.068 nGy h⁻¹. The ambient radon concentration in the air was found to vary from 5.55 to 18.4 ± 0.2 Bq m⁻³. Gross alpha and beta activities in common food commodities are shown in Table III.

Table III. Activity level in common food commodities

Sample	Milk	Chicken	Meat	Feeding Material	Grain	Vegetable
Gross α Activity (Bq/L or Bq/Kg)	7.5	<MDA	8.9	22.3	1.51	6.71
Gross β Activity (Bq/L or Bq/Kg)	255.3	146.9	92	570.7	229.7	264.4

Activity level in drinking water, surface and groundwater samples was measured. Tritium activity in all samples was below the MDA, The geometric mean for alpha and beta radioactivity was 0.37 and 0.42 Bq/L, respectively. In addition gamma-ray spectrometry analysis has been performed in all samples and activity level of ^{238}U , ^{226}Ra , ^{232}Th , ^{40}K and ^{137}Cs was below the MDA.

4. Conclusions

The results of design scenario demonstrate that the effect of surface water erosion scenario is acceptable. The results suggest that doses would still be well below the typical acceptance criteria, even with cautious assumptions likely to result in over-estimates of dose in surface water erosion scenario.

The activity concentration levels of the natural and artificial radionuclides were determined in the all samples collected from Anarak site and surrounding area using active and passive device. All results showed the background level of the natural and artificial radionuclides before any operation in Anarak Near Surface Disposal Facility.

5. Acknowledgements

This study was supported by the Operation Deputy Office, Dr. Ali Maleki, Mohammad Rostamnejad, Mohsen Asadian and Bahman Soleymanzadeh. We wish to express our warm thanks to Asghar Mohammadi, Fariba Hadian, Hamidreza Pakouyan, Nasrin Gourani, Fatemeh-mohammad Hosseinpour, Mohammad-ali Mohammadi, Amin Hemati, Taha Khaje-naeini, Arash Amin, Ali Iranpour and Morteza Sabeti.

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