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ENVIRONMENTAL RADIOLOGICAL MONITORING OF IĞDIR PROVINCE: 2013 – 2016

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IĞDIR İLİ ÇEVRESEL RADYOLOJİK İZLEME: 2013 – 2016

Abstract

"The monitoring of the radiological effects of nuclear power plants around Turkey" was added to TAEK's annual work programme as an ongoing activity for the purpose of monitoring the radiological effects of nuclear power plants around Turkey in 2013. As part of this activity, The Iğdır Region Environmental Radiological Monitoring Program was completed in 2015 (TAEK, 2015) and radiological monitoring studies were carried out within this program (TAEK, 2017).

Air, surface water, soil, drinking water and local food samples were collected and laboratory measurements were performed for the determination of environmental radioactivity levels. Environmental dose rate measurements were performed periodically by using the continuously operated RESA (Early Warning Environmental Radiation Monitoring System) units stationed in the region.

Detected radioactivity levels in drinking water samples were below the monitoring levels (Official Gazette, 2013). Maximum H-3 activity was detected as 0.82 Bq/m^3 and total indicative dose, for the measured Sr-90 and Cs-137 values, was calculated as 87.89 nSv/year considering the ingestion of drinking waters. When these values were compared with the stated values in the regulation (Official Gazette, 2013), for the indicative dose of 0.1 mSv/year, or for the limit value of 100 Bq/l for H-3, they were in conformity with the no further monitoring were needed conditions as for the H-3 activity, and for the other dose contributing nuclides in the drinking waters.

Özet

Türkiye'nin çevresindeki nükleer santrallerin radyolojik etkilerinin izlenmesi amacı ile 2013 yılından başlayarak TAEK yıllık çalışma programına "Türkiye'nin çevresindeki nükleer santrallerin radyolojik etkilerinin izlenmesi" isimli faaliyet eklenmiştir. Bu faaliyet kapsamında temel çalışma olarak "Iğdır Bölgesi Çevresel Radyolojik İzleme Programı" 2015 yılında tamamlanmış (TAEK, 2015) ve program dahilinde radyolojik izleme çalışmaları yapılmıştır (TAEK, 2017).

Bu kapsamda hava, yüzey suyu, toprak, içme suyu ve bölgede yetiştirilen ürünlerden gıda numuneleri alınarak laboratuvar ölçümleri yapılmış, periyodik olarak çevresel dozimetreler ve bölgede bulunan ve 24 saat kesintisiz çalışan RESA (Radyasyon Erken Uyarı Sistemi Ağı) istasyonları kullanılarak çevresel doz hızı ölçümleri yapılmıştır.

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İçme sularında tespit edilen radyoaktivite seviyeleri izleme gerektiren değerlerin altındadır (Official Gazette, 2013). İçme sularındaki H-3 aktivitesi 0,82 Bq/m^3 olarak ve içme suları nedeni ile sindirim yoluyla alınan toplam doz; ölçülebilen Sr-90 ve Cs-137 değerleri için toplam 87,89 nSv/yıl olarak tespit edilmiştir. Bu değerler Yönetmelikte (Official Gazette, 2013) gösterge dozu olarak belirtilen 0,1 mSv/yıl ile karşılaştırıldığında gösterge dozunu hesaplanmasına esas teşkil eden radyoaktivite açısından veya limiti 100 Bq/l olarak verilen H-3 açısından izlemenin gerekli görülmediği durum ile örtüşmektedir.

Keywords: Environmental radioactivity, Ionizing Radiation Measurement and Monitoring, Metsamor NPP, Radiation Dose Calculations, Radiation Protection, Radiation Measurement Systems, Radionuclides

Anahtar kelimeler: Çevresel Radyoaktivite, İyonlaştırıcı Radyasyon Ölçümü ve İzleme, Metsamor NGS, Radyasyon Dozu Hesaplamaları, Radyasyondan Korunma, Radyasyon Ölçüm Sistemleri, Radyonüklitler

1. Introduction

Environmental radiological monitoring programs for nuclear facilities were established and implemented as part of the radiation protection practices to assess the possible radiological effects on the environment and the public, from site assessment to disposal, as a license requirement. Depending on the power of the reactors and the number of units, off-site environmental monitoring programs can be extended up to 20-30 km from the plant (IAEA, 2010), (Russian Federation Ministry of Health, 2003), (IAEA, 2005).

The Metsamor nuclear power plant is 28 km away from Yerevan, the capital of Armenia. VVER-440/230 type consists of two units. The first unit was commissioned in 1976 and the second unit was commissioned in 1980. After the 1988 earthquake in 1989, it was decided to close the plant with a regulation by the Soviet Union. In 1993, the Armenian government decided to re-operate Unit 2, started work on plant safety and re-established the plant in 1995. Unit 1 is in the process of long-term closure and the decision to discontinue the plant has not been taken. There is also a used fuel dry storage facility in the facility area and used fuels of Unit 1 are kept in this facility (Republic of Armenia, 2001).

In order to determine the possible radiological effects that Metsamor nuclear power plant may cause on Iğdır and its surroundings during normal operation, Iğdır region environmental radiological monitoring program (TAEK, 2014) has been prepared and carried out in accordance with the Environmental Radiological Monitoring Directive for Nuclear Facilities (TAEK, 2014).

This programme aims to achieve the following issues:

- Monitoring of liquid and gas emissions from the Metsamor NPP to the environment,
- Obtain routine measurement results in order to make a comparison in order to determine how much the environment is affected in case of a possible accident,
- Determination of possible long-term radiological changes in Iğdır and surrounding environment,
- Calculation and evaluation of the dose taken due to the drinking water consumption within the scope of the "Regulation on Water Intended for Human Consumption" (Official Gazette, 2013),
- The evaluation of the program results in terms given limitations.

The studies were carried out under the coordination of TAEK-Nuclear Safety Department, sampling and laboratory analyzes were performed by ÇNAEM – Çekmece Nuclear Research and Training Center (changed as TDD after July, 2018) and SANAEM – Sarayköy Nuclear Research and Training Center (changed as DRAT after July, 2018).

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Standard methods and quality control systems, of ÇNAEM and SANAEM, particular to analyzes, were used for sampling and analysis.

2. Materials and Methods

2.1. Collection of samples

Eleven sampling locations were determined within the Metsamor nuclear power plant centered 30 km radius area within our borders (TAEK, 2015). Samples were taken in accordance with the sampling procedure (TAEK, 2017). Sampling locations and sample types were shown in Figure 1.

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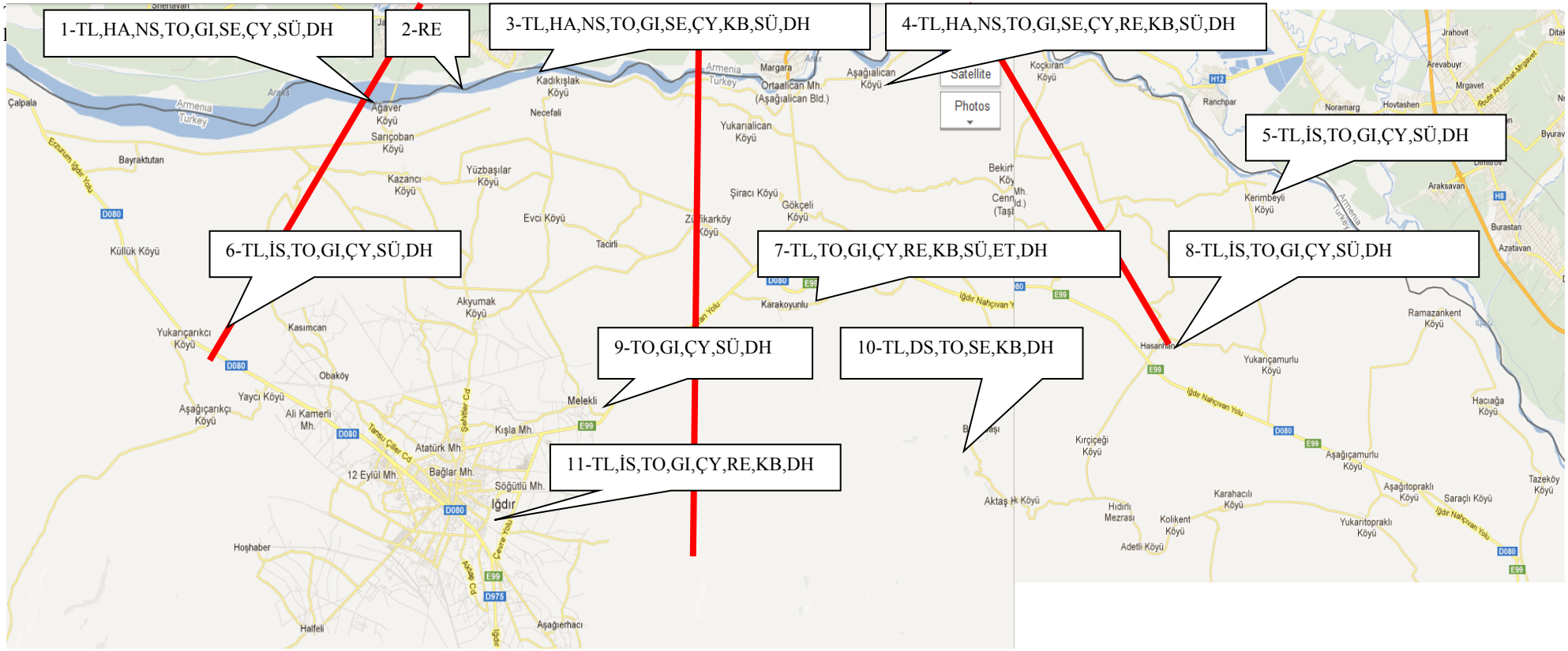

Figure 1: Sampling locations and sample types (TL: TLD, HA: Mobile air, İS: Drinking water, DS: Stagnant water, NS: River water, TO: Soil, GI: Foodstuff, SE Sediment, ÇY: Grass and feedstuff, RE: RESA, KB: Terrestrial plant, SÜ: Milk, ET: Meat, DH: Dose rate)

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The sample types, locations, number of samples, sampling frequencies and the types of analyzes were given in Table 1 for 2013-2016.

Table 1: Number of samples per sampling period versus types of sample and analyzes

Sample Class	Analysis Type	October 2013	December 2013	March 2014	May 2014	June 2014	July 2014	September 2014	November 2014	December 2014	05-15.03.205	23-31.05.2015	20-30.06.2015	22-24.06.2015	19.01.2015	27.03.2015	01.06.2015	Particular Sample Type
Meat	I-131, Cs-134, Cs-137, Sr-90	1					1	1										
Air	I-131, Cs-137, Sr-90, Total alpha, Total beta	12		12	12	4	12	6	15	12	8	8	8					(carbon and paper filters were accounted as different samples for the same date and same locations)
Drinking water	Cs-137, Sr-90	4				4		4										
Terrestrial plant sample	I-131, Cs-137,Sr-90	12					4	3						8				Grass, weed, willow leaf, poplar leaf, sycamore leaf, arborvitae
RESA	Total gamma	C*	C*	C*	C*	C*	C*	C*	C*	C*	C*	C*	C*	C*	C*	C*	C*	Alican, Iğdır, Karakale, Karakoyunlu
Aquatic plant sample	I-131,Cs-134, Cs-137, Sr-90, Total alpha, Total beta						2	1						1				Algae
Milk	I-131, Cs-134, Cs-137, Sr-90	7					8	8						8				
Foodstuff	I-131, Cs-134, Cs-137, Sr-90	25					21	57						18				Barley (dry), barley (fresh), pepper (mixed long green pepper), pepper (red), wheat (dry), wheat (fresh), apple, tomato, bean (dry), bean (fresh), needle, zucchini, watermelon, melon, apricot, rosehip, cabbage, corn (dry), corn (fresh), eggplant, cucumber, purslane, peach, sugar beet
TLD	Total gamma		9	9	9	9		9	9	9	9	9						
Soil	I-131, Cs-137, Sr-90	16					18	18						18				
Feedstuff	I-131, Cs-134, Cs-137, Sr-90	9					11	13						10				
Surface water	Cs-137, Sr-90	1				1		1						6				

C*: continuous

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Sampling activities continued until mid-2015, after this time, monitoring programme was limited only to monitoring with RESA for security reasons.

2.2. Preparation of samples and analyzes

The sample preparation methodologies and analyzes were performed in accordance with the instructions developed by the SANAEM and ÇNAEM. These methods and instructions were given in the report (TAEK, 2017).

2.3. Results and evaluations

Some of the planned samples were not taken;

- due to the necessary permissions from military security zones which could not be obtained in time,
- due to seasonal reasons and/or lack of product since no producer.

Some of the planned analyzes could not performed;

- due to product breakdown since the breakage of cold chain in food products,
- due to the absence of sufficient samples for analyzes after the occurrence of a situation requiring repetition of the analysis.

All the results of analyzes presented here were given in detail in the report (TAEK, 2017).

2.3.1. Food Samples Radioactivity Measurements

In monitoring period, a total of 121 samples from 24 different foodstuff collected from 10 (ten) locations in Iğdır region were analyzed. The concentrations of I-131, Cs-134, Cs-137, and Sr-90 were followed. After pretreatments such as drying, grinding, sieving, and homogenization, the samples were analyzed. The radioactivity of I-131, Cs-134, and Cs-137 radionuclides in the food samples were determined by gamma spectrometry and the radioactivity of Sr-90 was determined by liquid scintillation counting. The details of methods and instructions were given in the report (TAEK, 2017). The radioactivity of I-131, Cs-134, and Cs-137 for all foodstuffs were below the minimum detectable activity (MDA). The typical MDA value of I-131, Cs-134, and Cs-137 was 1 Bq/kg. The radioactivity of Sr-90 was measured in the range of 0.01 (MDA) to 6.37 Bq/kg.

2.3.2. Meat Samples Radioactivity Measurements

Meat samples radioactivity measurements were presented in Table 2 for the period of 2013-2014. Meat samples could not be taken for the period of 2015-2016. According to the laboratory analyzes, all the measurements were below the minimum detectable levels except Sr-90 analysis of 01/07/2014 dated sample.

Table 2: Meat sample radioactivity analyzes results (Bq/kg)

	28/10/2013				01/07/2014			09/09/2014		
	I-131	Cs-134	Cs-137	Sr-90	I-131	Cs-137	Sr-90	I-131	Cs-137	Sr-90
Karakoyunlu	<0.2	<0.1	<0.2	<0.84	<0.7	<0.5	0.21 ± 0.02	<2.7	<2.7	<0.11

2.3.3. Milk Sample Radioactivity Measurements

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There were some deficiencies in sample collection from Melekli Village and the highest radioactivity measurements by isotope types were;

- I-131, Alican Village, Kadıkışlak Military Post and Melekli Village samples<50 Bq/kg,
- Cs-134, Yukarıçarıkçı Village samples<3.4 Bq/kg,
- Cs-137, Kadıkışlak Military Post samples<22.7 Bq/kg,
- Sr-90, Ağaver Village and Alican Village samples: 0.09±0.01 Bq/kg.

2.3.4. Drinking Water Sample Radioactivity Measurements

Drinking water sample radioactivity analyzes results were presented in Table 3.

Table 3: Drinking water sample radioactivity measurements (Bq/m^3)

	October 2013	June 2014	September 2014	21-25 June 2015		
	Cs-137	Cs-137	Cs-137	Cs-137	Sr-90	H-3
Hasanhan Village	<2.80	<1.39	<1.28	<2.00	<0.26	0.69±0.04
Kerimbeyli Village	<0.67	<1.63	<1.02	<2.77	<0.30	0.72±0.04
Yukarıçarıkçı Village	<2.69	<1.00	<1.73	<1.71	<0.30	0.82±0.02

The following information was used to calculate the radiation dose from drinking water;

❖ For H-3;

o highest H-3 activity detected in water analysis was 0,82 Bq/m3 = 0,82 mBq/l = 0,82E-3 Bq/l

For the dose calculation

❖ Dose arising from Sr-90;

o daily liquid intake reference value for a male adult was 2 l/day (WHO, 1994),

o highest Sr-90 activity detected in water analysis was
= 0.30 Bq/m^3 = 0.30 mBq/l =0.30E-3 Bq/l,

o Ingestion dose conversion factor for Sr-90 was
= 2.8 E-8 Sv/Bq (ICRP, 2012)

$$\text{Dose} = 2\frac{\text{l}}{\text{day}} * 365\frac{\text{day}}{\text{year}} * (0.30\text{E}-3)\frac{\text{Bq}}{\text{l}} * (2.8\text{E}-8)\frac{\text{Sv}}{\text{Bq}} = 613.2\text{ E-11 Sv/year}$$

= 61.32 nSv/year

❖ Dose arising from Cs-137;

o daily liquid intake reference value for a male adult was 2 l/day (WHO, 1994),

o highest Cs-137 activity detected in water analysis was
= 2.8 Bq/m^3 = 2.8 mBq/l = 2.8E-3 Bq/l,

o Ingestion dose conversion factor for Cs-137 was 1.3E-8 Sv/Bq (ICRP, 2012)

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$$\text{Dose} = 2\,\frac{\text{l}}{\text{day}} * 365\,\frac{\text{day}}{\text{year}} * (2.8\text{E}-3)\,\frac{\text{Bq}}{\text{l}} * (1.3\text{E}-8)\,\frac{\text{Sv}}{\text{Bq}} = 2657{,}2\text{E-}11 \text{ Sv/year}$$

$$= 26.57 \text{ nSv/year}$$

- The total dose taken by ingestion due to drinking water; for measurable Sr-90 and Cs-137 values was = 61.32 nSv/year + 26.57 nSv/year = 87.89 nSv/year<0.1mSv/year.

Ingestion dose due to drinking water was calculated as 87.89 nSv/year by using the measured Sr 90 and Cs-137 values. H-3 activity was 0.82 Bq/m^3.

According to the rules of "Regulation on Water for the Purpose of Human Consumption" (Official Gazette, 2013) H-3 activity was less than the limit value of 100 Bq/l and the calculated dose value was less than the indicative dose value of 0.1 mSv/year. This requires that follow up was not necessary due to the drinking water radioactivity.

2.3.5. Surface Water Sample Radioactivity Measurements

Some of the planned samples could not be taken because of security problems. The highest radioactivity measurements are;

- Cs-137, Kadıkışlak Village, Aras River sample<4.44 Bq/kg,
- Sr-90, GTHM (Provincial Directorate of Food, Agriculture and Livestock - Gıda Tarım ve Hayvancılık İl Müdürlüğü) garden water sample<1.84 Bq/kg,
- H-3, Aktaş Village, lake water sample=1.42 ± 0.02 Bq/kg.

2.3.6. Rain Water Sample Radioactivity Measurements

According to the results of radioactivity analyzes in rain water samples taken from Iğdır center; there were some deficiencies in sampling and the highest radioactivity measurements were;

- Total alpha=0.071±0.018 Bq/kg,
- Total beta=0.273±0.023 Bq/kg.

2.3.7. Radioactivity Analyzes Results in Air Samples

According to the results of radioactivity analyzes in air samples; There were some deficiencies in sampling, the highest radioactivity measurements in laboratory analyzes were presented below.

In paper filter analyzes:

- I-131, Alican Military Post air sample<0.130 mBq/m^3,
- Cs-137, all locations of samples taken<0.1 mBq/m^3,
- Sr-90, DATAE air sample=0.066 ± 0.0080 mBq/m^3,
- Total alpha, DATAE air sample=1.32±0.20 mBq/ m^3,
- Total beta, DATAE air sample=2.84±0.23 mBq/m^3.

Carbon cartridge analyzes:

- I-131, Alican Military Post air sample<0.90 mBq/m^3.

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- Cs-137, all locations of samples taken<0.3 mBq/m^3.

2.3.8. Radioactivity Analyzes of Soil Samples:

According to the results of radioactivity analyzes in soil samples, there were some deficiencies in sampling and the highest radioactivity measurements were presented below.

- I-131, Yukarıçarıkçı Village, 0-20 cm deep soil samples<11.0 Bq/kg,
- Cs-137, Hasanhan Village, 20-40 cm deep soil samples=25.3 ± 3.8Bq/kg,
- Sr-90, Kadıkışlak Village, 0-20 cm deep soil samples=12.69 ± 0.13 Bq/kg.

2.3.9. Radioactivity Analyzes of Terrestrial Plant Samples:

According to the results of radioactivity analyzes in terrestrial plant samples, there were some deficiencies in sampling, the highest radioactivity measurements were presented below.

- I-131, GTHM samples<10.6 Bq/kg,
- Cs-137, GTHM samples <11.6 Bq/kg,
- Sr-90, Melekli Village samples=8.84 ± 0.70 Bq/kg.

2.3.10.Radioactivity Analyzes of Feed Samples:

According to the results of radioactivity analyzes in feed samples, there were some deficiencies in sampling, the highest radioactivity measurements were presented below.

- I-131, Aktaş Village samples<12.4 Bq/kg,
- Cs-134, Yukarıçarıkçı Village samples<3.7 Bq/kg,
- Cs-137, Kerimbeyli Village samples<16.2 Bq/kg,
- Sr-90, Alican Village samples=4.58 ± 0.37 Bq/kg.

2.3.11. Radioactivity Analyzes of Aquatic Plant Samples (Algae)

The results of radioactivity analyzes in algae samples were given in Table 5.

Table 5: Radioactivity analyzes of Algae Samples (Bq/kg)

	01-02/07/2014				09/09/2014				23/06/2015			
	Total alpha	Total beta	I-131	Cs-137	Total alpha	Total beta	I-131	Cs-137	Total alpha	Total beta	I-131	Cs-137
Aktaş Village	<34.10	142.40 ± 16.10	-	-	82.69 ± 45.15	635.96 ± 59.17	<2.9	<2.2	72.0 ± 42.12	231.0 ± 41.4	<17.0	<5.0

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Yazlık Village	-	-	<5.0	<5.0	-	-	-	-	Sample could not taken	Sample could not taken	Sample could not taken	Sample could not taken

2.3.12. RESA Monitoring Results

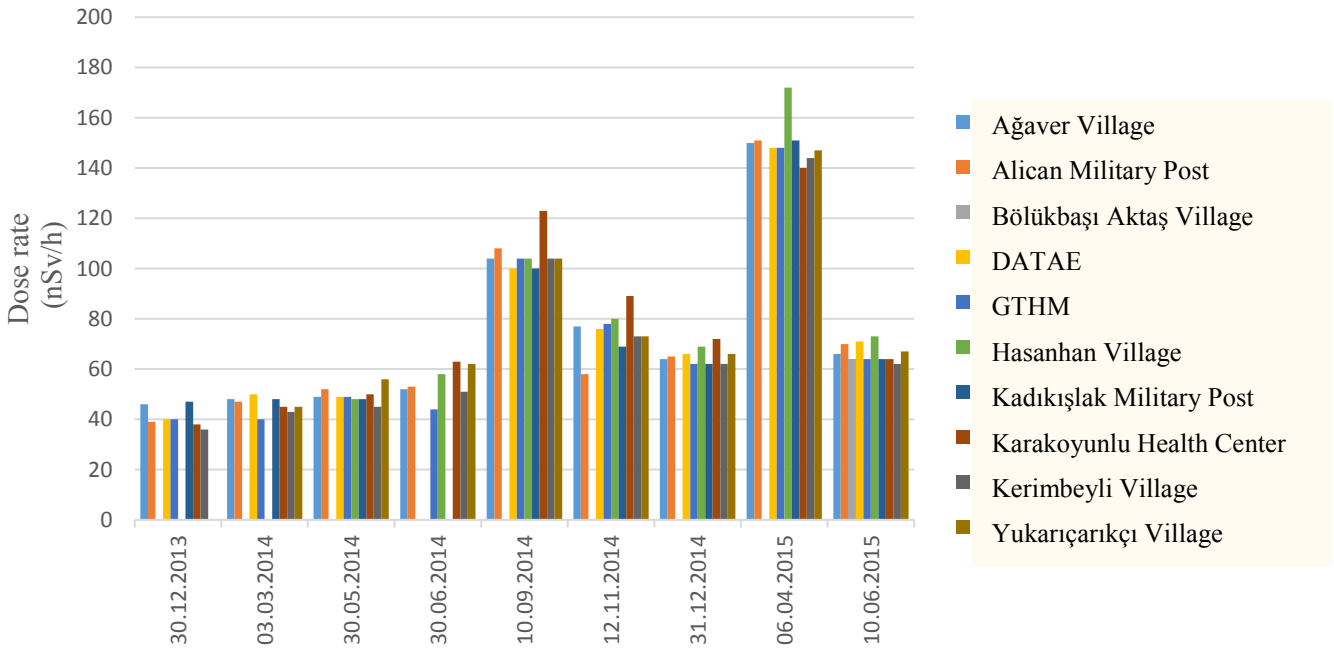
The yearly dose taken from the background radiation of 2.4 mSv/year (WNO, 2016) was divided by the 8760 hours equals to 274 nSv/h. This value was rounded to 300 nSv/h which was used as the warning level at RESA stations. This warning level was not exceeded in any measurement during 2013-2016 period.

Data analyzes for RESA stations were done over the median values and presented as below;

- Alican 80 nSv/h,
- Iğdır 60 nSv/h,
- Karakale 90 nSv/h,
- Karakoyunlu 70 nSv/h.

2.3.13. TLD Monitoring Results

Environmental gamma dose rates were measured in Ağaver Village, Alican Military Post, Bölükbaşı Aktaş Village, DATAE, GTHM, Hasanhan Village, Kadıkışlak Military Post, Karakoyunlu Health Center, Kerimbeyli Village, Yukarıçarıkçı Village by using the environmental TLDs (Thermoluminescent Dosimeter). TLD results were presented in Graph 1.



Graph 1: Gamma dose rates measured by using TLD

3. Conclusions

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A brief summary of Iğdır region environmental radiation monitoring programme results were presented in this study for the period of 2013-2016.

Within framework of the programme, the highest measurements were observed as follows;

- I-131, Alican, Kadıkışlak and Melekli milk samples<50.0 Bq/kg,
- Cs-134, Karakoyunlu beet sample<0.7 Bq/kg,
- Cs-137, Hasanhan soil sample=25.3 ± 3.8 Bq/kg,
- Sr-90, Kadıkışlak soil sample=12.69 ± 0.13 Bq/kg.

Ingestion dose due to drinking water was calculated as 87.89 nSv/year and radioactivity of H-3 was measured as 0.82 Bq/m^3. Since radioactivity of H-3 and dose value were both less than the limit values, follow-up was not necessary due to the radioactivity level of drinking water.

Based on the radiological dose assessments and surveys of radioactive contamination, NPP-induced radioactivity was shown any significant levels during monitoring period in Iğdır.

In conclusion, according to the analysis and measurement results within the framework of the monitoring program, no unusual findings were observed.

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