"ECOMET-S" JSC Experience in the Remediation of the former Balkanabat Iodine Plant NORM Contaminated Territory - 11451

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ABSTRACT

Continuous extraction of the iodine, bromine and other elements from the underground mineral waters at the Balkanabat Iodine and Khazar chemical plants (Turkmenistan) resulted in their territories NORM contamination and significant waste quantities formation. The bulk quantity of the accumulated production waste is represented by the sand, soils and charcoal mixture. Charcoal was originally used for iodine adsorption units feed. In the given report the material related to the Balkanabat Iodine plant territory remediation project is presented. The data on the adsorption plant buildings and facilities condition, contamination characteristics and waste quantities are indicated. It is shown that that the mechanical method has been chosen for contaminated materials disposal with their further placement to the specially constructed repository. Main demolition, remediation and transportation decisions and operations, equipment and containers are mentioned. Repository brief characteristics are mentioned also. The results of Balkanabat Iodine plant territory remediation are presented.

INTRODUCTION

Iodine, bromine and other minerals extraction sites radiation safety is the issue for the some of the former USSR Republics. Aged plants have been shut down years ago because of the out of the date technologies and worn-out equipment. Usually there are no any radiation monitoring systems and staff providing personnel, population and environment radiation safety and negative influence elimination. The most dangerous sites are the ones which are situated in the Caspian Sea coastal area. Under the Decree No.8639 of the President of the Turkmenistan dated 23/05/2007 the remediation works at the Khazar and Balkanabat sites have been initiated. After open competition "ECOMET-S" JSC was appointed as the contractor for these projects. In 2009 the parties signed the contract, and "ECOMET-S" JSC started to realize the "Safe transportation and disposal of the "Turkmenchem" State Concern Balkanabat Iodine and Khazar chemical plants technologically enhanced radioactive waste" project. The works waste majority is charcoal sorption shops demolition, territories remediation, production waste conditioning and transportation to the repository, providing further safe storage. The repository has been built in the natural, 6-8m deep hollow near Aligul' borough. The distances from repository to Khazar and Balkanabat sites are 9 and 120 km respectively. The project design has been done by VNIPIET, Saint Petersburg. The co-designing institution was Federal Radiological Center / NIIRG from the same city. In accordance with the contract all designed documents have been based on the Russian Federation and Turkmenistan legislation and norms. The following paper describes the Balkanabat iodine plant remediation project stage.

BALKANABAT IODINE PLANT CHARCOAL ABSORPTION SHOP BRIEF CHARACTERISTIC

The iodine and bromine have been extracted by the adsorption technology from the underground mineral water at Balkanabat (Nebit-Dag) Iodine plant since 1970 and till 1983. Because of radionuclides' presence in water the adsorption technology implementing caused their simultaneous accumulation in the adsorption units and adsorbents [1, 2]. Generally Ra-226 (U-238 series), as well as Ra-224 and Ra-228 (Th-232 series) define the natural radioactivity of the mineral waters and precipitate on the adsorption media. As the result, the significant amounts of the radioactive waste mainly in the form of charcoal, were accumulated at the territory of the Balkanabat Iodine plant The waste is referred to the NORM contaminated production waste according to Sanitary Rules of the Russian Federation (SP) 2.6.1.1292-03 [3]. According to the process, the charcoal after 10 cycles was off-loaded to the storage site, which is a main temporary storage at the present time. The minor part of charcoal is situated in the adsorption tanks and air separator. There are some contaminated areas in the close proximity to the adsorption shop.
The absorption building consists of 3 pavilions. The absorbers have been installed in two of them (48 units totally). The major part of the third pavilion was used as the washing department. Two reinforced concrete decanters are situated there. The rest of the building is occupied by the crystallization and pressing department, pumps, iodine warehouse and other auxiliary facilities. The shop was out of operation for more than 20 years. The building is destroyed. The adsorption shop appearance before remediation works is presented on the fig. 1.

Fig.1. The Balkanabat Iodine plant adsorption shop.

The estimated NORM contaminated waste quantities were as follows:
- charcoal and sand loose mixture– 1120 MT;
- used timber stuff – 80 cu. m;
- Construction rubble and building parts – 614 cu. m;
- Soil and rocks, including those which were moved out of the plant territory by the different actions and processes – 257 cu. m.

The adsorption shop site before remediation works start is presented on the fig. 2.

Fig.2. The adsorption shop site of the Balkanabat Iodine plant.

The radioactive elements composition in the waste is the following: Ra-226 – 80% including associated decay products (U-Ra series); Ra-228 – 19.99% including associated decay products (Th series); K-40 – 0.01%. The dose capacity over the waste (charcoal absorbent) was 1 –5 μSv/hour, at the depth of 0.5 m – 5 μSv/hour. The dose rate over the other NORM contaminated production waste was 0. 5 – 1 μSv/hour. The estimated maximum charcoal specific activity was 7.63×10^4 Bq/kg.

During the radiation survey in 2009 the specialists from NIIRG have carried out a detailed gamma-radiometry of the former adsorption shop production site, as well as of the operating production site. The survey objective was to find out and map the contaminated areas with the waste subject to collection and subsequent transportation to the repository. The total number of discovered contaminated zones within the former adsorption site a and operating facility amounts 9 with the maximum dimensions from one up to dozen meters and with the depth up to 2-3 m. Radionuclides' effective specific activity in the NORM waste was defined for all local radioactive anomalies.

Industrial waste category was specified according to SP 2.6.1.1292-03. [3] The industrial wastes classification basing on the NORM radionuclides' specific activity is presented in the Table I.

Table I. NORM contaminated industrial waste categories.

Waste category	Effective specific activity (SA_E), kBq/kg	Dose capacity (DC), μSv/hour
I	≤ 1,5	≤ 0.7
II	1,5 < … ≤ 10,0	0.7 <…≤ 4.5
III	> 10,0	> 4.5

a. Gamma radiation dose capacity was measured at the distance of 0.1 m from waste surface in accordance with the authorized procedures. The calculated DC values in the Table 1 correspond to upper limit values for the different waste categories.

According to the SP the following treatment methods are provided depending on the waste category:
- The category I waste management, including collection, temporary storage, transportation and disposal at the general dump sites is carried out without any restrictions in the terms of radiation safety.
- The category II waste management is carried out in the course of its further use. The order and conditions of their collection, temporary storage, transportation, treatment and disposal should provide the dose limits for personnel and population as specified in SP 2.6.1.2523-09 and NRB-99/2009) [4]. Sanitary and epidemiological inspection report should be issued by authorized body prior the works beginning.
- The category III (LLW) waste management is carried out in accordance with SP 2.6.1.2612-10 and OSPORB 99/2010(radioactive waste management guidelines) [5].

The estimated category II waste volume ($1.5 < SA_E \leq 10.0$ kBq/kg) is about 2500-3200 cu.m. The category III ($SA_E > 10$ kBq/kg) waste volume with higher NORM contamination was estimated within 1100-1700 cu. m. The category I waste volume has not been estimated.
Charcoal actual maximum specific activity is 5.94×10^4 Bq/kg according to survey results.
The most hazardous factors at the adsorption shop site are as follows:
- Increased gamma-radiation levels in the zones of the spent charcoal and materials after regenerators' repair storage.
- Radon (Ra-222) discharge (Thoron almost totally degrades in the charcoal).

The dose capacity around the former iodine production site is presented in the Table II.

Table II. The dose capacity around the former iodine production site.

Place	The dose capacity, μSv/hour
near the adsorption site	0.7-1.5
near scrubbers	0.13
at the adsorption site	3
above the absorbers with spent charcoal	up to 15
at the entrance gate of the iodine crystallization shop	0.3
inside the iodine crystallization shop	0.05-0.1
under the air separators	0.15-1
above the air separators (4 m from the charcoal)	1.2
charcoal sludge sumps	up to 6
Ra^{226} contaminated timber stuff	up to 3

Except above mentioned areas the gamma-radiation level at the plant territory is natural, 0.1-0.15 μSv/hour in particular.

THE REPOSITORY BRIEF CHARACTERISTIC

The TENORM repository was built in a desert area, in the natural 6-8 m deep hollow in Aligul` place, 9 km from the Khazar chemical plant. The nearest settlement is Azizbekovo township which is situated 5 km to the west from the repository. There are no any open water sources or ponds in this area. The repository is situated at 7 km distance from the Caspian seaside. Area seismicity is 9 magnitudes. The distance to the Balkanabat Iodine plant is 120 km.

A reinforced-concrete tank is used as storage facility, it`s dimensions are 81.8 x106.8 m. The depth is from 5.44 to 11.44 meters. The tank bottom dimensions are 80.0 x 105.0 m. The square is 8,400 sq. m. The volume is 42000 cu. m. Repository appearance is presented on the fig. 3.

Fig. 3. The TENORM repository.

According to the NIIRG radiation survey it was defined, that the TENORM repository and it's neighboring territory within 100 m from outside borders have rather stable radiation background of 0.1 – 0.22 μSv/hour search radiometer indications. Dose capacity ranges from 0.09 to the 0.13 μSv/hour. NORM effective specific activity of the storage repository structures, neighboring territory grounds and soils is in the range of 120-190 Bq/kg. Most feasible SA_E value is about 150 Bq/kg. There are no near surface radiation anomalies in the repository structures, neighboring territory grounds and soils within 100 m distance. According to the project documents the repository's shielding coating consists of the several layers with the different purpose. 0.5 m thick sand layer is to be dumped over the waste, placed into repository up to the walls' height. 3-5 mm thick bentonite layer is laid over the sand as the waterproof isolation media. The bentonite layer is overlapped to prevent moisture penetration. Also it will totally coat the repository outside walls. The basin pockets are filled up with the sand. Again 0.5 m sand layer is to be dumped over bentonite. Geotextile 6 mm thick film should be placed over as a separating, filtering and protective media. The clay loam comes over. Its thickness should be at least 1 m over the repository ends. Because of the slopes the clay loam thickness has to be increased also in the middle of the repository. The absolute repository height mark is 28.5 m. The slopes' inclinations are designed to provide the whole ground stability. The repository is equipped with appropriate drain system for the water collection during filling, shielding process and after the closure. According to the safety norms 6 wells will be provided for the possible radionuclide migration detection. Radiochemical analysis samples collection and the ground water levels detecting will be performed.

TERRITORY REMEDIATION CRITERIA AND TECHNICAL SOLUTIONS

The criteria for the Balkanabat Iodine plant charcoal adsorption shop site remediation had been chosen aiming its further industrial and construction planned use. According to OSPORB 99/2010 [5] the areas with the penetrating gamma-radiation dose capacity of up to 0.6 μSv/hour and radon discharge rate from ground surface within construction site perimeter of less than 250 mBq/(sq. m. X sec) should be selected for industrial buildings and structures erection. These rates were recognized as the criteria for the contaminated territories remediation.

The territory remediation method choice was defined by the industrial waste, grounds and soils contamination volumetric nature. Therefore the mechanical method was adopted for contaminated materials removal. This method provides decontamination to the desired levels and the safe contaminated materials transportation to the repository. It will also prevent further neighboring territory contamination, driven by natural and economic migration factors.

The following remediation actions should be undertaken:

- Contaminated materials mechanical removal from the charcoal adsorption shop;
- Excavated trenches filling with the pure grounds;
- Garbage and debris collection and removal;
- NORM contaminated waste collection and transportation to the repository;
- Waste placement into the repository.

Full existing buildings' dismantling was chosen because of the non-radioactive nature of the new technology which will be implemented at the newly built facility. All the buildings, main and auxiliary equipment, adsorbent charcoal sludge storage facility will be dismantled.

I category NORM contaminated industrial waste is transported to the landfill, which was established in 20 km from the plant. II and III category TENORM waste is shipped to the repository.

According to project design contaminated charcoal adsorption shop site remediation is divided into phases:

I phase is preliminary. It provides infrastructure development, in particular:

- Access area establishment,
- Project temporary buildings construction,
- Equipment, materials and containers purchase.

Temporary fence, incoming transport check point, personnel radiation detecting and decontamination facility and outbound transport decontamination point were installed during the adsorption site access area establishment.

Permanent fence, check point, personnel radiation detecting and decontamination mobile unit and transport decontamination point were installed during the repository access area establishment.

II phase is the charcoal adsorption shop demolishing. It includes:

- Buildings and their basements dismantling,
- Territory remediation,
- NORM contaminated waste collection, segregation and conditioning,
- Non-contaminated debris and I category waste transportation to the landfill,
- NORM contaminated waste safe transportation to the repository,
- Temporary infrastructure decommission preparation (decontamination works),
- Repository filling up.

III phase is repository closure. NORM contaminated waste safe storage.

VI phase is the temporary infrastructure final decommission.

For the safe transportation of the NORM contaminated waste to the repository the project documents prescribe KTBN-3000 and UKTN-24000 transport containers use [6]. Both containers were designed and implemented by "ECOMET-S" JSC for the solid LLW transportation. The basic transportation unit is UKTN-24000 (acronym stands for "Universal large-capacity transport container"). It is filled with 10 Big-Bag type primary packages (1cu. m volume, 1500 kg capacity) or 5 KTBN-3000 containers.

The following operations were carried out during buildings and equipment dismantling works, as well as during remediation:

- Buildings and equipment radiation measurements;

- Waste segregation according to physical nature and dose capacity;
- Main and auxiliary equipment, buildings external surfaces' decontamination (if necessary);
- Buildings and equipment dismantling and fragmentation;
- Metal fragments decontamination (if necessary);
- Timber fragments and debris burning;
- Dust suppression by watering;
- Waste packing into containers, their dosimetric inspection, package and vehicle decontamination (if necessary),
- Waste recycling or transportation to the landfill, or to the repository.

Dust suppression measures were provided to prevent contaminated materials' winds carry-out and emissions during wasted charcoal collection. The suppression was performed by watering up to 20 % humidity and more.

Construction debris, as well as grounds, soils, sands, charcoal (II category) and charcoal / soil mixture with the soils domination (III category) resulted from the remediation activities and categorized as II and III category waste was collected by wheel loader (fig. 4),

Fig. 4. The wheel loader.

belt conveyor and Big-Bags' filling station, which is represented at the fig. 5.

Fig. 5. Big-Bags' filling station

After being filled the Big Bags are passing the radiation inspection and characterization (weighting and marking). Then they are placed into UKTN-24000 container and directed with the accompanying documents to the repository. At the repository transport container is being discharged. The Big Bags with the II and III category waste are disposed.

II, III category metal industrial waste was collected into KTBN-3000 transport containers, which were placed into UKTN-24000 and directed to the repository after radiation inspection and characterization.

Spent adsorbent charcoal was collected by the industrial vacuum cleaner into 1.5 cu. m Big Bags.

Charcoal collection using VacTrailer S-4 industrial vacuum cleaner is represented at the fig. 6.

Fig. 6. Waste collection with the industrial vacuum cleaner.

WORK PERFORMANCE

Before remediation start a few preparatory actions have been undertaken, namely radiological survey, project documents and remediation criteria working out and approval, “ECOMET-S” JSC Turkmenistan branch establishment and register. All I phase sub works were performed according to project documentation, including infrastructure construction, purchasing campaign etc. Repository technical inspection has been carried out. Basing on the inspection results a lot of repository reinforcement and sites’ preparation work has been done. Demolishing and remediation works started in 2009.

By May, 2010 adsorption shop was demolished. Category I waste from the charcoal adsorption shop site of Balkanabat Iodine Plant was collected and transported to the landfill. Both operations were accomplished in a strict accordance with the norms, specifications and project documents.

By July, 2010 all the buildings and concrete structures were demolished. Site full remediation was performed. II and III category waste was packed and prepared for transportation.

Altogether 3888 Big-Bags (4138 cu. m in total) with II category waste were packed and prepared for the transportation to the repository. III category waste volume amounted 15 cu. m (10 Big-Bags with adsorbent charcoal).

Charcoal adsorption shop site with Big-Bags filled with the waste and ready for transportation is shown at fig. 7.

Fig. 7. Charcoal adsorption shop site after main remediation works finishing.

6 VOLVO trucks with two container-trailers were used for UKTN-24000 containers' transportation to the repository. For transport operations performance appropriate licenses and authorizations were obtained from the State Standards Office (Gosstandart), Health Inspection Services, Home Office, Emergency Situations Ministry and Ministry of Public Health.

Wastes' removal and disposal into the repository were completed in August, 2010. Transportation was carried out in accordance with the Sanitary Rules and Norms (SanPiN) 2.6.1.1281-03 [7]. 195 trips were made. Transportation experience confirmed that waste transportation UKTN-24000 containers using is safe and doesn`t represent any danger for the personnel, population and environment. There were no any emergency cases, accidents or deviations from the normal conditions for the whole transportation campaign. The generalized data on Balkanabat are presented resulted in the tab. III.

Table III. Iodine plant charcoal adsorption shop site remediation campaign results.

Site initial contamination levels (gamma radiation capacity)	0.18-9.8 mSv/hour
Site residual contamination levels (gamma radiation capacity) after remediation	0.09-0.19 mSv/hour
Waste initial effective specific activity	0.17-19.1 Bq/g
Grounds (sand, soil) effective specific activity after waste removal	0.18-0.24 Bq/g
Remediated area	4,500 sq. m
I category waste carried to the landfill (debris and grounds)	7,750 cu. m
Decontaminated metal waste (scrap metal) released for unrestricted use	67.3 MT
II category waste transported to the repository	4,138 cu. m (3888 Big Bags, 390 trips)
III category waste transported to the repository	15 cu. m (10 Big Bags, 1 trip)
Disposed waste total activity	up to $9x10^9$ Bq

Personnel absorbed individual radiation dose (within 6 months)	1-2 mSv

Balkanabat Iodine plant charcoal adsorption shop site appearance after remediation is represented at the fig. 8.

Fig. 8. Balkanabat Iodine plant charcoal adsorption shop site appearance after remediation.

Post-remediation radiation inspection has confirmed that the average equivalent gamma-radiation dose capacity doesn`t exceed 0.15 μSv/hour, radon discharge rate from the ground is less than 100 mBq/(sq. m x sec). Thereby the desired remediation criteria were significantly overfulfilled. This means, that the effective dose for the enterprise staff working at this site will not exceed 1mSv/year which corresponds to population dose limit.

FINAL STATEMENT

Remediation activities allowed returning of the former adsorption shop territory into the production cycle and provided safe and secure plant operations. One of the Turkmenistan's most hazardous sites was eliminated. An essential NORM contaminated waste volume was safely transported and disposed for the long-term storage under the regular environment monitoring.
The gained experience could be used in the other NORM-related remediation projects including those were underground mineral waters are involved. Estimated the whole project "Safe transportation and disposal of radioactive TENORM waste from Khazar Chemical and Balkanabat Iodine plants of State Corporation Turkmechem" deadline is December, 31st, 2010. Repository warranty operation will be provided until December, 31st, 2012.

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