Environmental Radiation Monitoring at the Areas of the Former Military Technical Bases at the Russian Far East - 12445

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ABSTRACT

After termination of operation at the serviced facilities of the nuclear fleet of the former Soviet Union, the Military Technical Base in Sysoeva Bay has been reorganized to the site for SNF and RW temporary storage (STS). The main activities of STS are receipt, storage and transmission to radioactive waste reprocessing. Establishment of the RW management regional centre in the Far-Eastern region at the STS in Sysoeva Bay implies intensification of SNF and RW management in this region that can result in increasing ecological load to the adjacent areas and settlements. Regulatory supervision of the radiation safety at the areas of the Former Military Technical Bases at the Russian Far East is one of the regulatory functions of the Federal Medical Biological Agency (FMBA of Russia). To regulate SNF an RW management and provide the effective response to changing radiation situation, the environmental radiation monitoring system is arranged. For this purpose, wide range of environmental media examinations at the Sysoeva Bay STS was performed by Burnasyan Federal Medical Biophysical Centre – a technical support organization of FMBA of Russia in collaboration with the Federal State Geological Enterprise «Hydrospecgeology» (Federal Agency for Entrails).

INTRODUCTION

In the 1960s, the coastal technical base (today—site for temporary storage (STS)) of the Pacific Fleet was created in the Far East region of the USSR in Sysoeva Bay at Primorskiy territory 40 km away from the Vladivostok port. This STS was used to service nuclear submarines performing reception and storage of spent nuclear fuel (SNF) and radioactive waste (RW). In the late 1980s and 1990s, overall decommission of the nuclear fleet began, mainly due to the termination of the operational life of ships and vessels and the necessity to observe obligations on implementation of the USSR–American Agreement on strategic nuclear forces [1]. A large amounts of SNF and RW were accumulated there. After the expiration of the designed service life, the infrastructure of the facilities degraded resulting in serious potential hazard of radioactive contamination of the environment. According to the Russian Federation Government Directive, in 2000 [2], this base was transferred under authority of Russian Ministry of Atomic Energy (the Minatom of Russia, since 2008 - the State Atomic Energy Corporation “Rosatom”) for the purpose of its remediation [3]. At present, STS in Sysoeva Bay is a part of the Far-Eastern Centre for radioactive waste management «DalRAO» which is under economic management of Rosatom. The operator (Rosatom) is fully responsible for radiation protection and safety at the facilities during the RW and SNF management.

FMBA is the official regulatory body at the Rosatom's facilities. It is responsible for independent control and supervision (fig. 1). The regional managements and centers of hygiene and epidemiology located in the radiation hazardous areas of facilities are the key FMBA affiliated divisions responsible for practical implementation of regulatory supervision of radiation safety and protection. Burnasyan Federal Medical Biophysical Centre (FMBC) is the organization for scientific and technical support of the regulator (FMBA) and the principal task of FMBC is the scientific and methodological support to independent regulatory control of radiation safety and protection as well as development of criteria and safety standards remediation of contaminated lands taking into account special features of radiation hazardous facilities inspected. Regulation of the RW and SNF management is continuous process, which the FMBA of Russia implements in close cooperation with other Russian responsible authorities. This paper deals with results of collaborative work of FMBC and Federal State Geological Enterprise «Hydrospecgeology» (Federal Agency for Entrails) on examination of radioactive contamination of ground waters at the STS in Sysoeva bay.

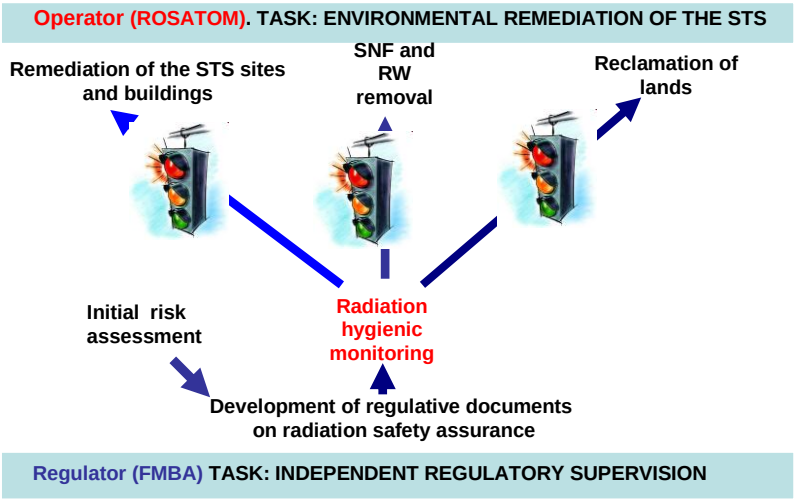

Fig.1. Organization of Independent Regulatory Supervision of the STS Facility

MATERIALS AND METHODS

In order to obtain comprehensive information with respect to current radiation circumstances at STS, the STS facilities are subject to radiation-hygienic monitoring carried out in 2009-2011. More than 150 samples of environmental media were collected in Sysoeva Bay and nearby settlement (Staryj Dunaj village) for this purpose during three expedition travels.

The objects examined included: soil, vegetation, ground water, sea water, bottom sediments, local foods (milk, meat, vegetables, berries, mushrooms, etc). Sampling was carried out according to the requirements of the standard recommended procedures described in official documents on methods of sanitary control of radioactive material contents in the environmental media and foods. In addition to examination of the environmental samples, gamma dose rate has been measured. Gamma- spectrometry with and radiochemical methods were applied for sample measurements. Gamma spectrometric measurements of Cs-137 and Co-60 in water and bottom sediments of marine off-shore environment have been performed using MKS-01A gamma-spectrometer with NaI-detector.

ANALYSIS OF THE RADIATION SITUATION AT THE STS.

The nature and peculiarity of the STS area radioactive contamination on the Far East are the following: 1) high levels of local radioactive contamination on the industrial site; 2) non-uniformity of the contamination distribution; 3) spread of contamination in the area of health protection zone. The following buildings are the main sources of the environmental contamination on the industrial sites: liquid RW (LRW) processing, the LRW storage facility, the solid RW (SRW) storage facility (close to other surface buildings), the trench type storage facilities, site for the SRW temporary storage, SNF storage facility, the pier area where SNF discharge from the nuclear submarines was carried out. The following environmental components are contaminated: soil, vegetation, bottom sediments and seaweeds at the offshore seawaters. The dominant radionuclides are Cs-137 and Sr-90.

Specification of areas within the STS

With the purpose of radiation protection of workers and the public, the following areas are specified on-site and around the STS site (fig.2):

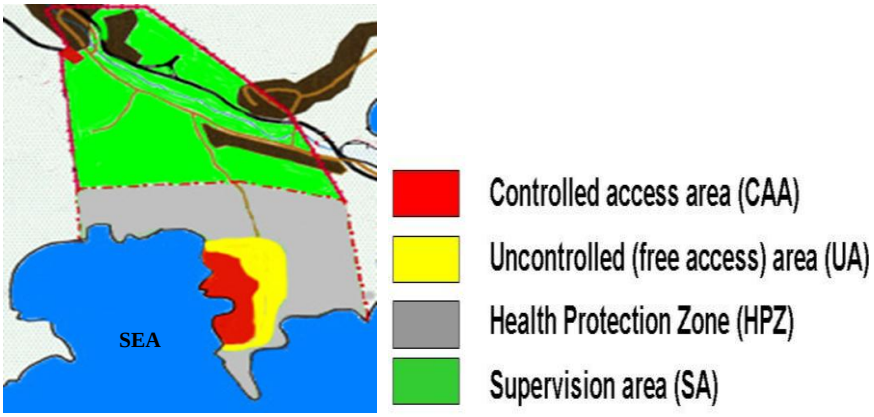

Fig.2. Specification of areas within the STS in Sysoeva bay

- Controlled access area (CAA-red) – SNF and RW store facilities are located here and radiation-hazardous operations are being performed here too;
- Uncontrolled (free access) area (UA-yellow) – Facilities intended for work supplying in the CAA;
- Health protection zone (HPZ-grey) – This is an area of administrative and technical provision of the STS;
- Supervised area (SA-green) – This is an area surrounding the STS, where radiological monitoring is being carried out to guarantee radiation safety and protection for the public

The uncontrolled access to the first three areas is forbidden.

Industrial site

When the STS in Sysoeva Bay was under transfer to the Ministry of Atomic Energy authority, gamma dose rate at 90 % area of the radiation sites (industrial site) was higher than the natural background typical for this place; at some parts of the site it reached 100 μSv/h. Since 2001, radiation situation has become more stable and on- and off-site contamination spreading decreased due to conducting remedial measures before the beginning of building operations,

cleaning up the most contaminated parts of the site, improvement of auxiliary drainage system for ground water. The current gamma dose distribution at the STS is shown on fig.3.

Fig.3. Gamma dose rate distribution at the STS in Sysoeva Bay (2010)

Gamma dose rates varied over a wide range within the STS territory (0.1-13 µSv/h), this exposure resulted from radioactive materials inside radiation facilities (facility for RTG, SRW and LRW storage), and radiation originated from the contaminated soil. Along the perimeter of the STS area, gamma dose rate varied over the range from 0.051 to 0.68 µSv/h. The specific activity of soil varies over the range from 450 to 32500 Bq/kg for Cs-137 and from 350 to 35000 Bq/kg for Sr-90. To study the special features of the ground water radioactive contamination and to find potential pathways of ground water discharge into the sea offshore water area, the comprehensive geological and hydro-geological examination of entrails has been carried out together with FSUGE «Hydrospecgeology» within the STS. Geological and hydro-geological conditions of the site are rather complicated. The reason is the complicated tectonics, as well as changing natural hydro-geological conditions due to redesign of the site, communication laying and presence of sporadic ground water. After the activities performed, the observation network of 24 hydro-geological boreholes (6.5 – 33.3 meter depth) was created in 2010.

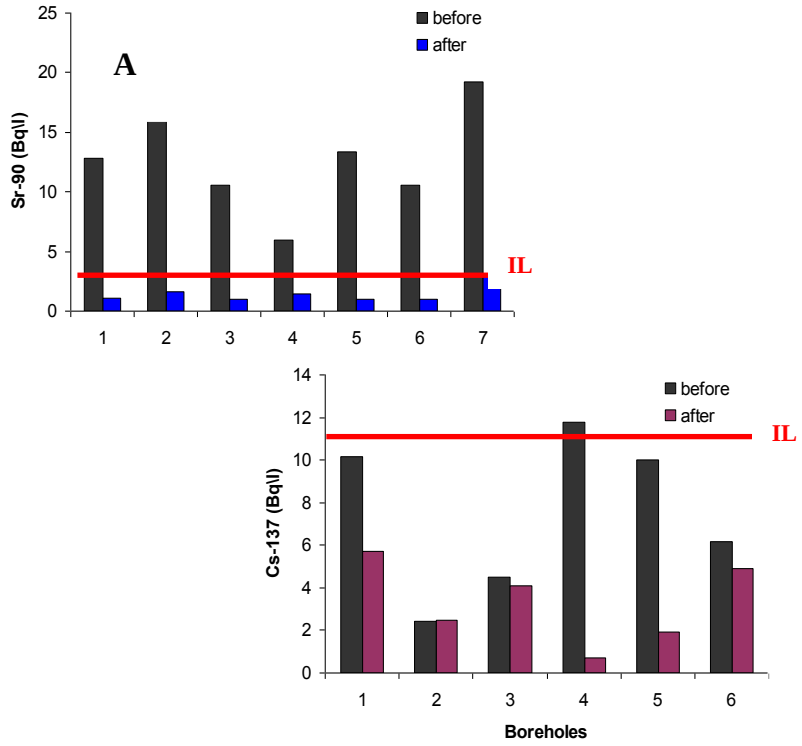

Fig.4. Radio-chemical analysis of ground water samples before and after protective measures (Measurements were performed after intensive fallouts of 13-14th July, 2011. (IL-intervention level)

Monitoring of the ground water conditions in the boreholes was performed including radio-chemical examinations of water samples, measurements of the ground water level and temperature [6]. The drilling operations assumed the following filtration scheme in a vertical section: In the areas of bulk soils, the precipitations in rain and snow melting seasons filter down freely, then, because of low permeability of underlying bedrocks, vertical movement slows down sharply, water does not seep down in the main horizon and spreads partly, forming lens of watered rocks. Due to the rather extensive net of the operational communications, the main discharge of sporadic waters occurs via these networks. Analysis of the examination performed shows that almost throughout the industrial site both ground and surface water is contaminated. The main contaminators are Sr-90 and Cs-137. Maximum radionuclide specific activity registered in water samples was: Sr-90 – 23.42 Bq/L (4.78 IL[7]) and Cs-137 – 11.76 Bq/L (1.07 IL[7]). The first findings show that soils and disused communications contaminated with the radionuclides near SNF storage facility are the main sources of contamination of ground and drainage water. The radionuclide appearance was registered during the intensive fallouts (or snow melting), when contaminated soils are washed out and radionuclide desorption takes place. In 2011, in the course of inspections to find the center of contamination of entrails by generation of artificial filling the boreholes and wells and tracing the migration ways of contaminated water, the center of the ground water contamination has been found and localized in the area of the SNF storage facility. Comparative results of radio-chemical analysis of the ground water samples collected from the boreholes before and after taking the advised protective measures and repair of the damaged water pipe are presented on fig.4. Due to the performed protective measures, the regular decreasing specific activity of Sr-90 and Cs-137 has been registered in almost all boreholes inspected over 2011.

Health protection zone

Following the radionuclide leaching from the man-made soils via snow melt and rainy water, radioactive contamination spreads beyond the industrial sites and to the coastal offshore waters. Beyond the STS (health protection zone (HPZ), there are three local parts of the area on the coast and in the off-shore water area, contaminated with man-made radionuclide. The first covers the slope of the bank precipice and a part of bank behind the construction 'Sheltering' (fig.5. location #1). The ground contamination at this area results from the LRW leakage from the construction 'Sheltering'. In 2005, the covering was built above the 'Sheltering' construction, so penetration of atmospheric fallouts and melted snow in the construction was prevented and anti-filter protection around the facility has been built. These measures reduced the process of radionuclide release into the environment. Nevertheless, soil contamination on the bank reaches $3*10^4$ and $6*10^4$ Bq/kg for Cs-137 and Sr-90, respectively. The specific activity of the man-made radionuclides in the environmental marine media in some areas of the sea offshore water within the HPZ reaches 350 Bq/kg and 3665 Bq/kg in bottom sediments, and 98 and 142 Bq/kg in seaweeds, for Cs-137 and Sr-90 respectively.

Fig.5. Localization of artificial radionuclide contaminated areas within health protection zone at STS in Sysoeva bay.

The second part is located in 45 m to the south from the SRW storage facility (fig.5. location #2). The most contaminated parts are in the precipice in the bed of the brook passed through. The STS experts consider radioactive substances that entered into the soil from the SNF emergency cooling pool as the main source of the brook water contamination. Soil contamination in the bottom of the brook reaches $1.2*10^3$ and $1.4*10^4$ Bq/kg for Cs-137 and Sr-90, respectively. The dose rate and soil contamination with radionuclides in the brook sediments decreases significantly with the

distance both from the STS and from the brook bed in normal direction. About 30–40 m from the STS border, the brook goes underground. Therefore, gamma dose rates at the remaining part of the area down to the sea are 0.1–0.15 μSv/h. The third part of the area is located in the coastal zone of Sysoeva Bay near the root part of the pier (fig.5. location #3). The end of the pier is the most contaminated (gamma dose rate varies from 1.2 to 13 μSv/h). At the remaining part of the pier, the dose rate varies over the range from 0.11 to 0.53 μSv/h.The radionuclide contents in soil at this area reach $3.6*10^3$, $2.8*10^3$ and 19 Bq/kg for Cs-137, Sr-90 and Co-60, respectively.

To study radioactive contamination of the offshore waters, in 2011, bottom sediments were examined using the underwater scintillation gamma spectrometer (fig.6). The center of radioactive contamination (bottom gamma dose rates reach 20 μSv/h) has been identified nearby the pier, where nuclear fuel reloading and decontamination of ships involved in mitigation of the Chazhma incident consequences were carried out. Surface activities of artificial radionuclides reach: 10^5 Bq/m^2 for Cs-137 and Co-60. The examination of the marine offshore water in the area of the Strelok Bay (fig.5. location #1) did not find radioactive contamination of the sea bottom. More detailed examination of this part of the sea offshore waters is planned to be carried out next year.

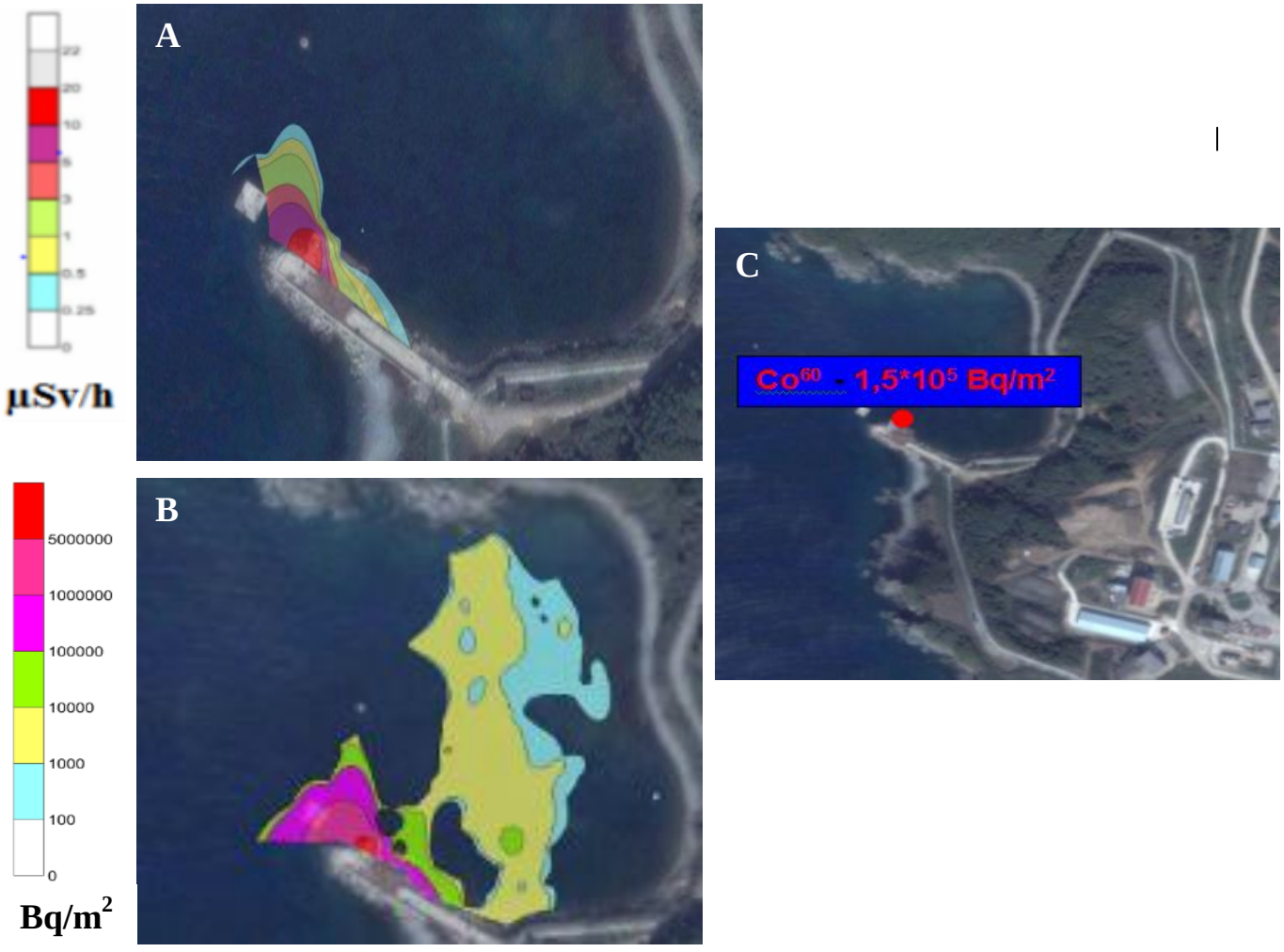

Fig.6 Radiation monitoring of marine bottom sediments. Pier. Sysoeva Bay. 2011.
A. Gamma dose rates distribution of bottom sediments (μSv/h)
B. Surface density of Cs-137 distribution in bottom sediments (Bq/m^2)
C. The localized area of Co-60 contamination of bottom sediments

Supervision area

To obtain comprehensive information about influence of STS activities on the public living close to the radiation hazardous facilities radiation-hygienic monitoring of living areas in supervision area has been carried out. Beyond the STS, up to the nearest settlement (Staryj Dunaj village - 3 km away from the STS), the radiation situation generally corresponds to the natural background typical for such an area dose rate varies over the range from 0.10 to 0.15 μSv/h; specific activities of Cs-137 and Sr-90 in soil vary over the ranges from 13 to 25 and 4 to 5 Bq/kg, respectively. Exclusions are some parts of the road, which passes along the village (at least 50 m distance from the dwellings) and from the village to the STS. These parts of the road have been contaminated during conveyance of the damaged SNF to the STS for storage. Despite the decontamination performed, at the 2.2 km part of the road along the village, the specific activity in soil on the side reaches 300 Bq/kg for Cs-137 and 290 Bq/kg for Sr-90.For the purpose of the radiation situation monitoring during SNF and RW transportation, the decision has been made to locate the thermo-luminescent dosimeters close to the road passing near the residential area. Time, place of location and frequency of monitoring have been agreed with the radiation monitoring service of the facility. At the lawns along the road, where the local residents pasture their domestic animals, the specific activities of Cs-137 and Sr-90 in soil reach 22 and 34 Bq/kg, respectively. The results of artificial radionuclide distribution in the components of the food chain are presented in table I.

Table I. Contamination of the food chain components

Sample	Specific activity (Bq/kg)	
	Cs-137	Sr-90
Soil (0-10cm) (pasture)	6.7-21.7	6.4-34
Grass (pasture)	1.1-8.8	1-9.2
Goat milk	0.3	0.1

According to measurements, the radiation situation at the inhabited area of the village remained the same in 2011. Table II includes the summarized data on the radionuclide contents in the local foods, mushrooms and wild berries, and sea fish caught near the STS.

Table II. Contamination of the foodstuff

Foodstuff	Specific activity (Bq/kg)	
	Cs-137	Sr-90
Cow Milk	0,4	0,1
Potato	0.4-11.7	0.2-7.2
Mushrooms	13.8-34.2	1.2-9.5
Wild berries	1.2-2.8	0.2-3.5
Sea fish	0.9	0.1

These data have been obtained by the experts from the STS and FMBC. The specific activity values given in table II are more than 10 times lower than the authorized Russian levels.

CONCLUSIONS

Regulation during the RW and SNF management is continuous process, which the FMBA of Russia implements in close cooperation with other Russian responsible authorities – the State Atomic Energy Corporation “Rosatom” and Federal Agency for Entrails. The Environmental radiation

monitoring findings served as a basis for the associated databank arrangement. The radio ecological monitoring system was arranged at the facilities under inspection for the purpose of the dynamic control of the radiation situation. It presupposes regular radiometry inspections in-situ, their analysis and assessment of the radiation situation forecast in the course of the STS remediation main stages. Some new data on the radiation situation at the facilities will appear in future and the prognostic assessment will become more precise. The mentioned natural, practical and theoretical works is a base for the development of the set of regulatory documents to assure radiation protection and safety of workers, public and environment, as well as development of documents to regulate SNF and RW management at the STS facilities.

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