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Cooperation between State Research Center – A.I. Burnasyan Federal Medical Biophysical Center of Federal Medical Biological Agency of Russia and Norwegian Radiation and Nuclear Safety Authority

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Key words: *radiation safety, nuclear legacy, regulatory supervision, radiation health physics monitoring, emergency preparedness and response, international cooperation*

For citation: Shandala NK, Sneve MK, Semenova MP, Segien K, Filonova AA. Cooperation Between State Research Center – Burnasyan Federal Medical Biophysical Center of Federal Medical Biological Agency and Norwegian Radiation and Nuclear Safety Authority. Medical Radiology and Radiation Safety. 2020;65(1):72-78. (In Russ.).

DOI: 10.12737/1024-6177-2020-65-1-72-78

Since 2004, the professionals of State Research Center – Burnasyan Federal Medical Biophysical Center of Federal Medical Biological |Agency (SRC-FMBC), together with specialists from the Norwegian Radiation and Nuclear Safety Authority (formerly NRPA, since 2019 – DSA), have carried out a number of research and practical projects on regulating radiation safety at the sites of nuclear legacy of the Northwest Center for Radioactive Waste Management SevRAO – a branch of FSUE RosRAO (Fig.1). This work became the basis for the formation of methodologies for improving regulatory supervision of nuclear legacy sites [1, 2].

Since 2008, cooperation has continued under an agreement between the Ministry of Health and Social Development of the Russian Federation and the Ministry of Health and Social Services of the Kingdom of Norway "On cooperation in the field of regulation of the safe use of atomic energy in conducting health and epidemiological supervision of radiation hazardous work". This agreement was officially signed on November 13, 2008, by the head of the FMBA of Russia V.V. Uyba and NRPA director Ole Harbits.

Scientific and practical work carried out within the framework of cooperation is aimed at solving the following problems:

- Radiological threat assessment to identify regulatory priorities.
- Researches to assure radiation protection and safety of workers.

Fig. 1. Nuclear heritage sites in northwestern Russia

- Detailed radiation survey at sites, territories and in the vicinity of the facility.
- Control and monitoring of the environment.
- Improvement of safety culture of the personnel and increasing their performance reliability.
- Enhancing and maintaining emergency preparedness in the event of a radiation emergency.
- The development of computer maps and geo-informational systems.
- The development of regulatory documents.

During the cooperation, some scientific and practical studies were carried out related to the development of criteria and regulations for the remediation of the site for temporary storage (STS) of Spent nuclear fuel (SNF) and radioactive waste (RW) at Andreeva Bay, the assessment of doses to the personnel, conducting emergency exercises at the facility, and the direct organization of radiation health physics monitoring.

In the field of *radiation safety and protection of the personnel*, an informational and analytical system has been developed using the visualization technologies of the personnel routes and visualization of the radiation environment in workshops. This helped to:

- Find areas where radiation situation is known with the highest uncertainty, i.e., additional radiation survey is required.
- Predict individual occupational doses.
- Localize areas with the higher contribution to dose.
- Optimize transport flows during the personnel evacuation in case of potential radiological accident.

The analytical capabilities of the developed Andreeva Planner software consist in the creation and simulation of different scenarios for radiation hazardous operations, as well as in calculating both individual effective doses of each of the virtual participants in the work and collective doses. In general, the created software complex helped to reduce the uncertainty in the assessment of radiation exposure during occupational operations, i.e. have a more accurate idea of the potential occupational doses. This allows considering these developments as a working tool for optimizing and management decision making in order to prevent potential threats connected with overexposure of workers [3, 4].

Operation under abnormal conditions makes special requirements for monitoring the *professional reliability* of the personnel. In connection with this new direction, the scientific work on the creation of an anthropogenic (manmade) risk monitoring system has been developed, which allows assessing the impact of the human factor during complex SNF management operations. This is an expert diagnostic information system for express pre-shift assessment of the personnel professional reliability during nuclear and radiation hazardous operations. Moreover, a method for radiation safety culture assessment has been developed and internal assessment of such a culture at the Andreeva Bay STS was performed [5, 6].

Reliable information on the parameters of the radiation situation and the dynamics of its change is the basis for activities to optimize the public and environmental radiation protection at all stages of the STS remediation. The receipt and accumulation of this information is carried out during *radiation health physics monitoring.* In order to structure radio-ecological information and analyze changes in the state of environmental contamination during remedial activities, information systems have been developed that include detailed stores of data on environmental media contamination [7, 8].

Comparative analysis of the field work data allows representing the dynamics of changes at the facility, identifying areas of radioactive contamination of the environment and optimizing monitoring studies. The current research results allow us to state that a change in the radiation situation at the Andreeva Bay facility is characterized by a positive dynamics in the reduction of manmade radionuclides as in environmental media, including the offshore sea area. According to the results of monitoring of ground water contamination, the dynamics in reducing the levels of manmade radionuclides is positive.

An analysis of the data on the dynamics of changes in the gamma dose rate at the industrial site also testifies in favor of a positive tendency to reduce the upper limit of the gamma dose rate (Fig. 2). Dynamic changes in the dose rate distribution at the industrial site characterize the redistribution of zones of increased gamma dose rate, a decrease in their size and quantity, which is a reflection of the ongoing remedial work on the site for the RW management.

The high hazard potential of the accumulated SNF and RW, the need for work in abnormal conditions require the improvement of the *emergency preparedness and response* system in the direction of minimizing and mitigation of the consequences of possible emergencies. In this light, four large-scale international exercises and trainings were conducted at the Andreeva Bay STS: in 2006, 2009, 2016 and 2018.

In practice, the early warning procedure of the IAEA and neighboring states was trained for a suppositive radiation accident. In general, at the conducted emergency exercises, not only the organization of interaction between emergency response participants was improved, but also a wide range of tasks was worked out to provide medical assistance to the victims and conduct health physics measures in the aftermath of the accident [9, 10]. Representatives of a large number of interested ministries and departments took part in the emergency exercises, the media actively demonstrated these exercises, and special films were created for each exercise.

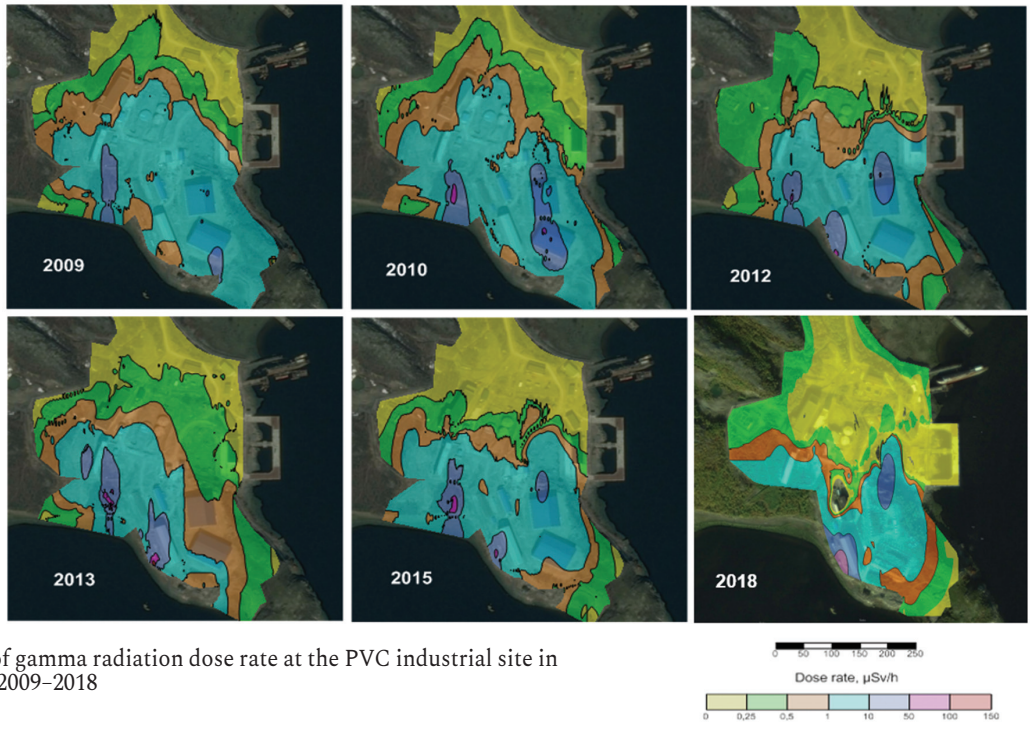

Fig. 2. Dynamics of gamma radiation dose rate at the PVC industrial site in Andreeva Bay for 2009–2018

Based on the results of monitoring and assessing existing risks, special regulatory documents have been developed that take into account the specifics of the facility at Andreeva Bay [11]. They include:

- requirements for radiation safety and protection of the personnel and population;
- requirements for the individual dose monitoring procedure;
- guidelines for the RW management including the very low level waste category;
- requirements for monitoring of the environmental media;
- requirements for the radiation monitoring procedure in the vicinity of the facility;
- requirements for remediation of sites in a form of the criteria and regulations of the remediation etc.

A set of scientific and practical work in the field of regulatory supervision during the remediation of a nuclear legacy facility at Andreeva Bay became the basis for the creation of the International IAEA Forum. The Forum on the Regulatory Supervision of Legacy Sites has been successfully operating over the recent nine years as a platform for discussing the results achieved by IAEA Member States [12].

The results of the work contributed to the organization of special working groups: 1) EGLM under the OECD Nuclear Energy Agency; 2) TG № 98 under ICRP. These groups contribute to the development of practical recommendations on existing exposure in territories contaminated due to the past nuclear activities.

In 2017, a massive removal of SNF began on STS at Andreeva Bay, which is planned to be completed by 2025 [13].

Today, SRC-FMBC continues its work under four projects of cooperation with the DSA.

The overall results achieved over the fifteen-year period of work are characterized by the following statistical indicators (Fig. 3):

- total completed projects – 30;

Fig. 3. Statistics of 15-year cooperation between FMBA of Russia and DSA

- involved specialists (experts) – 80 persons;
- 50 scientific papers published, including publications in peer-reviewed journals;
- 50 meetings were held on project progress;
- participation in 30 scientific conferences with presentations on the project materials;
- 4 international emergency trainings conducted;
- 20 regulatory documents of the health and epidemiological regulation system developed.

In general, the experience gained during the remediation of the former coastal naval technical base at Andreeva Bay helped to identify new relevant areas for improving regulatory supervision at nuclear legacy sites.

We associate the development perspectives of our further work in the framework of the Agreement concluded between the Ministries of Health of Russia and Norway in 2008 with the development of the following relevant areas in the field of environmental and health physics principles and fundamentals for regulating human radiation safety:

- Supporting regulatory supervision during the management of flooded and sunken facilities with SNF and RW in order to assure radiation safety and protection of the population and participants of the work, as well as protecting the environment during the planned lifting of flooded facilities with SNF and RW, their transportation, storage and reprocessing.
- Assuring the safety and protection of the population and workers under the impact of radiation and non-radiation factors at the stage of regulatory supervision during the management of SNF at the Mayak Production Association (during the processing of normal and abnormal SNF removed from the site of the NWC SevRAO, as well as SNF unloaded from the unit-packing FTB “Lepse”).
- Scientific support for the remediation of nuclear legacy sites and the decommissioning of nuclear power facilities. Object of study – research reactor in Halden (Norway), owned by the Institute of Energy Technologies (IFE), operated since 1958 and stopped in 2019.
- Collaborative research of SRC-FMBC and Section North DSA in Tromso (Norway) on comparing the results of the content of radioactive substances in environmental media (soil, water of open reservoirs and drinking water, terrestrial and marine vegetation, etc.) and foodstuffs.
- Assessment of radiological consequences of terrorist emergencies in the transportation of SNF.
- Assuring the radiation safety and protection during the management of very low level RW at the industrial site of the Center for the RW Conditioning and Storage at Saida Bay.
- Radio-ecological monitoring on the industrial site at Andreeva Bay and adjacent offshore seawater area.