Development elements of the information and measurement systems of mobile environmental monitoring

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Abstract. The article presents a proposal to improve the system of radioactive monitoring in the territory of St. Petersburg using an unmanned aerial vehicle equipped with a radiation detector. This radiation remote sensing device is essential to ensure environmental safety. The use of unmanned aerial vehicles equipped with sensors will make it possible to effectively obtain data on the radioactive contamination of the earth's surface and airspace. An un-manned aerial vehicle with a radiation sensor will allow you to receive data in real time. In the event of a potentially hazardous situation, this device will measure fluctuations in the dose rate distribution on the ground and can be used for radiation monitoring. For this purpose, an improved mobile radiation monitoring system has been created. The system consists of models whose functionality allows you to measure dose rates and create radiation pollution maps without the need for human personnel to be present at the measurement site. The convenience of the radiation monitoring system is the rapid deployment of unmanned monitoring devices to reduce the radiation burden on the population. The system can be used in any place where a source of ionizing radiation may be present. Before this system can be used in real-world conditions, its components are calibrated based on certified measuring equipment and state-of-the-art modelling tools.

1 Introduction

State control of radiation situation on the territory of the Russian Federation is carried out in order to detect changes in the radiation situation, assess, predict and prevent potential negative consequences of radiation exposure for the population and the environment. To control the radiation situation, the environmental community and the State are creating radiation monitoring systems. It is also used for a systematic presentation of relevant operational information to the public authorities controlling the use of atomic energy, government regulation of safety in use of atomic energy, organizations to take the necessary measures to prevent or reduce radiation exposure.

The state carries out monitoring through an automated system for monitoring the radiation situation (ASMRS). Automated system for monitoring the radiation situation in its current form solves only part of the task – it measures the power of the so-called ambient equivalent of the dose of external gamma radiation in the air, but it does not record the presence of alpha and beta emitters, as well as the composition of radioactive substances that can enter the environment.

Within the framework of the national security concept of the Russian Federation adopted in 2015, there is a problem of developing a system of taking preventive measures to reduce the risk of radiation accidents and their consequences on the basis of preventive measures.

The relevance of the study lies in the necessity and expediency of improving and developing object and territorial systems for monitoring the radiation situation (OTSMRS), which will use modern developments for reliable measurement of the level of radioactive pollution of the environment.

2 Methods

The automated radiation monitoring system operates in order to obtain operational information about the radiation situation in real time. This system provides control over the dose rate of external radiation on the territory of the city of St. Petersburg. At the moment, the system consists of 16 stationary monitoring stations that automatically monitor the radiation background. In addition to these posts, the radiation situation monitors in the North-Western Hydro-Meteorology and Environmental Monitoring Department at fixed points on a daily basis with the help of certified dosimeters. The results of monitoring information is posted on the website in the "Monitoring" section/Radiation situation".

We received data on the state of radiation monitoring from North-Western Hydro-Meteorology and Environmental Monitoring Department. According to the criteria for the hazard of hydrometeorological phenomena, the gamma-radiation exposure doses (GRED) value of more than 20 mkR/hour (0.2 MKR/hour) is considered a high level of environmental

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pollution, and the GRED value of more than 60 mkR/hour (0.6 MKR/hour) refers to extremely high pollution.

According to the observations, the average monthly values of the GRED in the region were observed in the range from 0.08 to 0.15 mSv / hour, and the maxi-mum value of the GRED up to 0.21 mSv/hour was observed on the island of Kronstadt, which is associated with the structure of the earth's crust and the presence of variations in cosmic radiation.

Starting from January 2018, the exposure dose rate of gamma radiation in the above-listed territories varied within the limits of the new values for the previous year.

2. Measurement of the gamma and total beta activity of aerosol samples

Sampling of radioactive aerosols is carried out with pentad exposures at 3 stations using airfiltering devices, which are located in St. Petersburg.

Under high pollution of the environment, a 5-fold increase in the concentration of total beta activity is assumed in comparison with the average daily values for the previous month, and under extremely high pollution– when the total beta activity exceeds the value of 3700x10-5 Bq/m3 per day.

The average monthly value of aerosol beta activity (OGMS Saint Petersburg) was 7.3 x 10-5 Bq / m3, and the maximum value of aerosol beta activity was 21.1*10-5 Bq / m3.

All values do not exceed the extremely high pollution value (3700x10-5Bq / m3 per day).

Gamma-spectrometric analysis of aerosol samples taken at the United State Hydrometeorological Station of St. Petersburg using a semiconductor detector did not show the presence of an unusual radionuclide composition. Trends in the deterioration of the radiation situation in the region based on the results of long-term measurements of the total beta activity of aerosols are not observed. The object of the study is the development of elements of a more advanced system for monitoring the radiation situation at radiation-hazardous facilities and other facilities in the Leningrad Region and St. Petersburg, which will help to inform the environmental community and regulatory authorities about the safe operation of these facilities more quickly and more fully.

The main tasks that need to be solved to improve automated radiation monitoring system are:

- analysis and assessment of the current state of the environmental monitoring system at radiation hazardous facilities in the Leningrad Region and St. Peters-burg,

- to analyse modern means of monitoring the content of noble gas radionuclides in the atmosphere, as well as to consider the possibility of creating a prototype of a mobile laboratory station for monitoring xenon and background levels of man-made radionuclides in the surface atmosphere;

- develop elements of a radiation monitoring system with the possibility of set-ting up not only stationary posts, but also the possibility of mobile monitoring;

development of facility and territorial systems of radiation monitoring (OSMRE) that use modern design to assess the level of radioactive contamination of the environment and meet the modern requirements of legal norms of national and international security. Calendar plan for the implementation of the project.

During the first phase of the project conducted a review and analysis of modern means of control of radionuclide noble gas (RNG) in the atmosphere, as well as the possibility of creating a prototype of a mobile laboratory monitoring station xenon and background levels of radionuclides in the near-ground atmosphere.

For the study, elements of a radiation monitoring system were developed with the possibility of installing not only stationary posts, but also mobile monitoring capabilities. The created prototypes of mobile radiation monitoring of the territory and potentially dangerous objects of St. Petersburg allow to inform the ecological community of the region with greater reliability and completeness. Part of the improved monitoring system will be an unmanned aerial vehicle with a dosimeter connected to it. Table 1 shows the elements improved monitoring system.

Table 1. Elements of improved object and territorial monitoring system radiation environment.

Name	Quality	Notes
Quadrocopter DJI Phantom 4 PRO V2. 0	1	Account number k020221 Date of registration in the register of the Federal Air Transport Agency 13.01.2021 Serial (identification) number 11USH8CR710042 Maximum take-off weight 1.375 kg
Dosimeter-radiometer "MKS-03SA"	1	Entered in the State Register

The equipment is part of the developed research protocol of the mobile radiation monitoring station and is necessary for further testing of the project in the field.

The importance of creating an improved system is high for St. Petersburg. According to statistics, there are 749 enterprises with ionizing radiation sources located in the city. Sources of radiation are natural, for example, unique natural objects, and artificial, in this case, a landfill. In addition, there are landfills on the territory of the city, where the territory was not examined for the presence of radiological danger.

The reasoned and reliable information received by the automated system about the radiation situation in the areas where radiation-hazardous facilities are located is intended to inform the city and regional public to confirm the safe operation of radiation-hazardous facilities.

Figure 1 shows elements of improving and developing object and territorial system for monitoring the radiation situation.

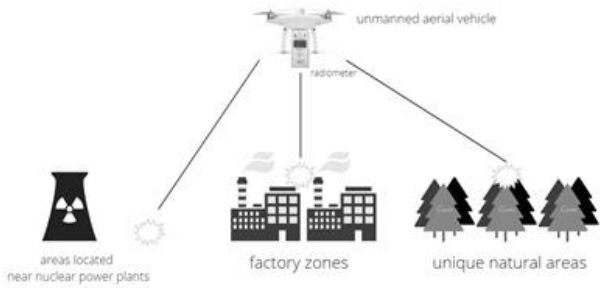

Fig. 1. Prototype of a mobile radiation monitoring system for use in various radiological exploration scenarios.

Of interest is the possibility of new radiation monitoring system earlier than the old radiation monitoring system warning of state bodies, the public and the population of St. Petersburg about the beginning of a radiation accident at a radiation-hazardous facility, which will allow taking adequate measures to protect the population and the environment from the damaging effects of radiation exposure. Figure 2 shows environmental map of St. Petersburg and the details of the location of the research object - the existing landfill.

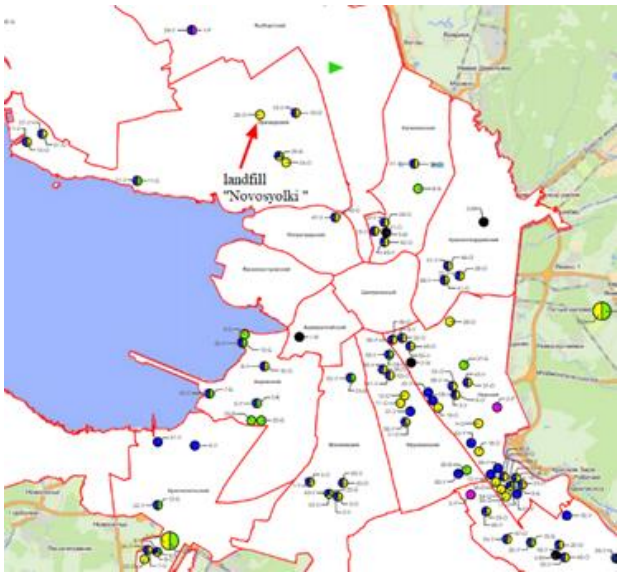

Fig. 2. Environmental map of St. Petersburg.

The map shows the object of the study-the Novoselki landfill, located on the territory of St. Petersburg. The route of an unmanned aerial vehicle was modelled for the territory of the landfill. The route of the unmanned aerial vehicle was modelled for the landfill area. After testing the prototype of the improved mobile monitoring system, we will be able to create a map of the area that reflects the level of radiation at each of these points. Figure 3 shows model of the route of an unmanned aerial vehicle with key points.

Fig. 3. Model of the route of an unmanned aerial vehicle with key points.

Simulation of the path of an unmanned aerial vehicle is used to assess the level of radioactive contamination of the environment in the landfill area.

3 Results

In the course of the study, the main scientific results of the work were obtained:

Elements of an information and measurement system for monitoring the radiation situation have been developed with the possibility of setting up not only stationary posts, but also the possibility of independent mobile monitoring using UAVs;

Designed object, and territorial monitoring system radiation environment (OTMSRE) that use modern design to assess the level of radioactive contamination of the environment and meet the modern requirements of legal norms of national and international security.

Based on the activities carried out, a research prototype of a mobile laboratory station for monitoring background levels of technogenic radionuclides in the surface atmosphere was developed.

The novelty of the study consists in the fact that research work in terms of analysing the current state of local environmental radiation monitoring systems for completeness and unification of data in accordance with the requirements of modern legislative, regulatory and legal norms of the state and international level in order to improve the industry-specific environmental monitoring system has not been carried out before.

In contrast to the existing ASMRS system, the proposed OTMSRE system meets the requirements, and not only records the radiation background on the territory, but also in fact is an early warning system for the population about possible accidents at radiation-hazardous facilities by monitoring xenon and background levels of man-made radionuclides in the surface atmosphere.

4 Discussion

In the course of the study, the main scientific results of the work were obtained:

- the possibility of creating a remote radiation monitoring system using an autonomous unmanned

helicopter installed with a dosimeter-radiometer to study the distribution of the dose rate of environmental radiation

- elements of the radiation monitoring system were developed with the possibility of setting up not only stationary posts, but also the possibility of independent mobile monitoring using UAVs;

- designed object, and territorial monitoring system radiation environment (OSMRE) that use modern design to assess the level of radioactive contamination of the environment and meet the modern requirements of legal norms of national and international security.

The results obtained fully correspond to the goals and objectives set in the work

Based on the activities carried out, a practical result was obtained — a research prototype of a mobile laboratory station for monitoring background levels of technogenic radionuclides in the surface atmosphere was developed.

5 Conclusion

Based on the conducted research, it is planned to develop a prototype of a mobile laboratory station for monitoring xenon and background levels of techno-genic radionuclides in the surface atmosphere. The significance of the research results for the development of environmental safety lies in the need and expediency of improving and developing object and territorial systems for monitoring the radiation situation. This system will use modern developments to assess the level of radioactive contamination of the environment and promptly inform the environmental community.

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