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Contents

Features Function of Radiation Monitoring System World's Countries of Developed Nuclear Energy

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Abstract Effective network radiation monitoring is essential for every country because the health of the personnel working at the dangerous radiation sites and the population living in the polluted territories depends on it. A critical analysis was carried out functioning different world countries; the main tasks that solve these networks are listed. Show the location of monitors on the maps, and the location of monitoring posts on maps are shown, and the hardware used for these purposes is demonstrated.

Keywords Radiation monitoring · Network · NPP · Radiation background

1 Introduction

Nowadays, many institutions and organizations are operating worldwide that use hazardous radiation technologies and sources of ionizing radiation in their activities. Such objects include nuclear power plants (NPP), research reactors, specialized plants for processing and storing radioactive waste, enterprises extracting and processing uranium ores, and medical facilities using radioisotopes. Oil, gas, coal

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industry, and heat energy enterprises also participate in the radiation situation formation. During their operation, there is a noticeable redistribution of natural radionuclides (uranium, thorium, decay products, potassium, etc.) in the environment. In addition, fuel for nuclear power plants and spent fuel assemblies are transported through many territories. All these objects are objects of increased danger because emergencies related to their activities can lead to highly complex consequences for the present and future generations due to uncontrolled (accidents) or controlled (terrorist act) release of a significant amount of radioactive substances into the environment. Therefore, one of the most critical components of the country's national security is the provision of nuclear and radiation safety [1–4].

One of the main aspects of nuclear and radiation safety is radiation monitoring in the territories where hazardous radiation facilities are located, which various legal acts regulate. From that place, the effective functioning of radiation monitoring networks is an essential task for every country of the health of personnel working at hazardous radiation facilities and the population living in contaminated areas.

2 Results of the Research

Radiation monitoring is an information and technical system of observation, assessment, and forecast of the radiation state of the biosphere. Radiation monitoring is a system of long-term repeated monitoring to assess the state of the radiation situation. Environmental radiation monitoring is a system of regularly monitoring the radiation state of the environment, migration, and accumulation of radionuclides, potentially dangerous phenomena, etc. The primary purpose of monitoring is to provide information to decision-makers.

We will list the main tasks of radiation monitoring [5]:

- observation and control of the state of the territory contaminated with radionuclides, its hazardous parts, and the development of ways to reduce the danger from contamination;
- assessment of the state of objects in the environment according to the parameters that characterize the radioecological situation both in the zone of pollution and outside it;
- identification of trends in changes in the state of radioactive contamination of the environment in connection with the operation of radiation-dangerous objects, as well as during the implementation of radiological protection measures carried out in pollution territories;
- elucidation of possible trends to changes in the state of health of the population living in radionuclides-contaminated areas;
- information provision of the forecast of the radioecological situation in the radionuclides pollution territories and the country in general.

Let's move on to analyzing the monitoring systems of different world countries.

2.1 Ukraine

At enterprises and organizations that create a radiation risk, there are radiation control services that take samples of air, soil, and water and carry out their laboratory analysis according to their regulations and schedule. At the NPPs of Ukraine, in their observation zones, in addition to periodic sampling, there are automated radiation monitoring systems (ARMS), which collect information in real time, store it for a long time and provide current and retrospective information about meteorological parameters, and radiation status at established monitoring locations. For example, such a system at the Khmelnytskyi NPP includes 15 radiation control container posts, four on the industrial site and others in a 20-km zone. Thus, nowadays, in the territories where radiation-hazardous objects are located in Ukraine, either non-automated sampling or stationary automated systems for monitoring the radiation situation are used for radiation monitoring.

By the regulations, the following it is carried out at NPPs of Ukraine:

- control of equivalent dose rate (EDP) and annual radiation dose on the territory in the area where the NPP is;
- measurement of contamination by radioactive substances of air, soil plants, snow cover, the water of open reservoirs, bottom sediments, agricultural products, and locally produced fodder;
- control of meteorological parameters in the areas where the NPP is located to assess the consequences of radionuclide emissions in the event of an accident;
- additional control of the environment when the established control levels of radiation parameters are exceeded and during planned and preventive repairs.

The website of UKRHMTs (https://meteo.gov.ua) constantly informs the public about the level of background radiation in the environment, based on the data received by the NGMS DSNS of Ukraine on the radiometric observation network, as well as on the available data of automated radiation monitoring systems of NPPs of Ukraine. According to the level of the radiation background of the environment, the monitoring zones of the NPP in September 2022, compared to the average monthly values, stayed within the accuracy of their determination. Increases in radiation background have yet to be recorded on the territory of Ukraine (Fig. 1) [6]. It should be noted that the results of daily measurements of the radiation background in recent months are only obtained from some observation points of the radiometric network of the NGMS due to the occupation of the territories or the conduct of hostilities with the Russian occupiers [7].

The website https://www.saveecobot.com/radiation-maps, which displays information about the environmental background radiation of Ukraine from various monitoring entities, is also worth paying attention.

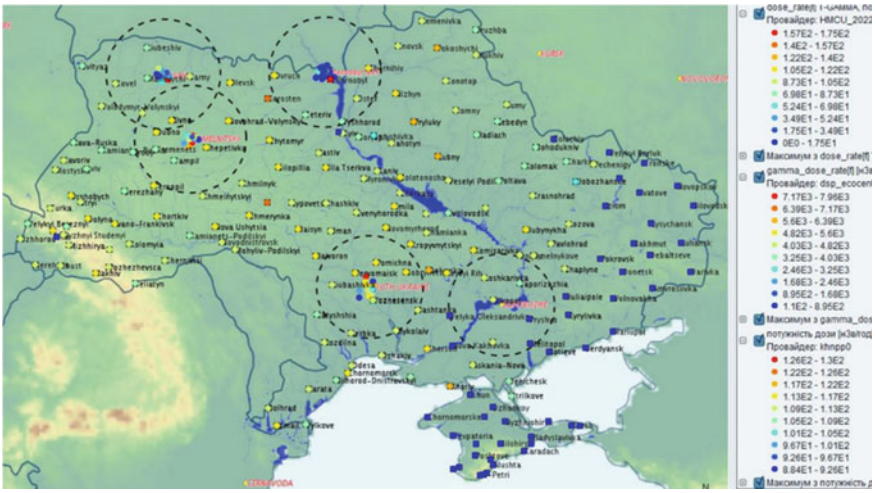

Fig. 1 Radiation background at the territory of Ukraine as the results observation network NHMS and ASCPS: DSP "Eco Centre" RNPP, HNP, PUNPP, as of 09:00(Kyiv) 5/09/2022 [6]

2.2 The USA

The nationwide RadNet system was created to observe environmental radiation pollution levels. System RadNet has tracked radiation levels from testings nuclear weapons and nuclear reactor accidents at Chornobyl nuclear power plant (Ukraine) and Fukushima (Japan). During a radiological incident, government officials use RadNet data to help make science-based decisions about protecting the population. In addition, scientists use the system RadNet state of radioactive air pollution monitoring data to help estimate the potential radiation dose to humans. Also, use metrological data during the estimated quantity [8].

RadNet has 140 stationary air monitors that run 24 h a day during the week and collect data near-real-time gamma radiation measurements. Figure 2 shows RadNet static air monitoring locations [8] and precipitation and drinking water sampling locations that reported data in 2020. Figure 3 shows up filters air radiation monitor system RadNet [9].

Under standard conditions, air monitors RadNet operates continuously, and samples of air, precipitation, and drinking water are analyzed on a planned schedule (Table 1) [10]. During a radiological emergency, the United States Environmental Protection Agency (EPA) can deploy teams to conduct air monitoring and environment.

RadNet system data are available in databases and reports. In addition, EPA publishes analytical and monitoring results after checking to ensure they meet high-quality standards.

Envirofacts RadNet Database includes laboratory analysis results from air monitor filters, precipitation sampling, and drinking water. Also, this database is historical

Fig. 2 RadNet stationary air monitors

Fig. 3 Filters air radiation monitoring

Table 1 Sampling frequency of the system RadNet

Medium	Sampling frequency	Testing frequency
Air filters	Continuous (real-time)	Continuous (real-time)
Precipitation	As rainfall, snow or sleet occurs	Monthly analysis of a composite sample
Drinking water	Quarterly	Quarterly

data about sampling milk. Finally, this database includes the current and historical data needed to estimate long-term environmental radiation trends [11].

As well United States Nuclear Regulatory Commission implements radiation pollution monitoring continuously in states in the USA, such as a sample of bioassay, alpha scans, a physical survey of the disposition of the materials and equipment, sampling or assessment levels to monitor air, surface water, and groundwater, soil, and sediment, equipment, and personnel [12].

2.3 India

Bhabha Atomic Research Centre created a nationwide network of radiation monitoring IERMON, including 25 stations across the country [13]. The main objective of the network is:

- providing online information about radiation levels in various;
- facilitating assessment of environmental impact from radiation emergencies;
- establishing background radiation levels in the environment.

The network's central station consists of both PCs; one is used for downloading from remote stations through "PSTN", and the other is for maintaining the database. Every station this network is equipped with (Fig. 4):

Fig. 4 Tools in the monitoring stations IERMON [14]

– GM counter-based radiation monitor;
– Ion Chamber based radiation monitor;
– high-volume air samplers for radionuclide identification;
– data acquisition and data exchange system.

The general feature of the network IERMON are:

– real-time measurement of ground-level external radiation dose;
– assessment of radioactivity in the air on a weekly;
– advanced data commutation facilities;
– redundancy provision for critical.

Network IERMON providest:

– online information about radiation levels in different locations in the country;
– data about background environment radiation level and long-term shift of background level;
– data about assessment of environmental impact after nuclear emergencies.

2.4 France

On the national level, monitoring the dose equivalent rate is carried out on all territories of France (Fig. 5) laboratory in the Institut de radioprotection et de sûreté nucléaire (IRSN). The automated detectors represent proportional counters manufactured by BITT Technology (Fig. 6) [15].

The measurement of the monitors transmitted through a multiprotocol label switching virtual private network (MPLS VPN) or a direct contract between the IRSN and a telecommunications operator, or under the agreement between the IRSN and the Gendarmerie Nationale. The monitoring system ensures receiving of the measurement data in a Microsoft SQL Server database. Each measurement result is automatically compared to a sliding reference average of one week's data. In addition, the measurement automatically checks if it is within the acceptable variation range ±40 nSv/h of this average indicator. Nevertheless, in other cases, size has to be manually validated by the Téléray remote sensing system [15].

The monitoring system operates in real time. It includes redundancy, a recovery plan, and an agreed service commitment from the network operator. Monitoring of the public radiation dose (passive dosimetry) is carried out using about a hundred dosimeters. However, today monitoring is carried out more and more frequently using tradio-photoluminescenceene (RPL) dosimeters (manufactured by the IRSN's dosimetry laboratory) [16]. The dosimeters are exchanged every three months.

The facility from nuclear fuel processing Orano La Hague has mobile equipment for monitoring discharges and the environment, whether on a routine basis or in other

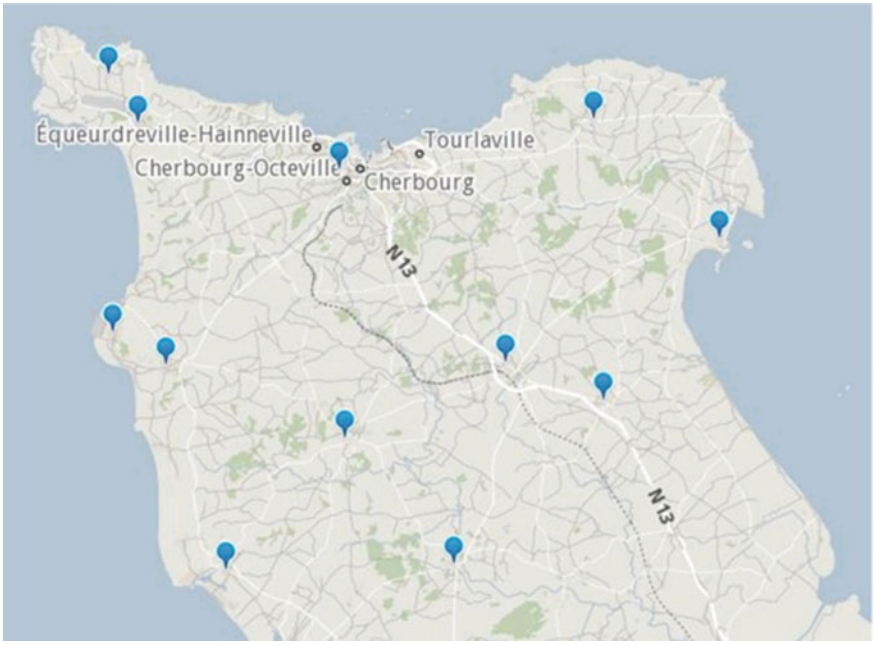

Fig. 5 Locations of the IRSN [16]

Fig. 6 BITT technology detectors [15]

emergencies. Four autonomous trailers are equipped with the following sampling and measurement equipment:

– system for sampling aerosols with continuous alpha/beta measurement;
– probe for continuous measurement of the ambient gamma dose rate;

– mobile sampling equipment allowing samples pf bio-indicators (grass, soil, water).

The measurement data and report are sent in real-time to the correspondent department. Each trailer has an electrical generator and a lighting system.

2.5 *Spain*

The Nuclear Safety Council (CSN) supervises the National radiological monitoring system consisting of a sampling station network and autonomic stations network. This network provides information about radioactive levels in staple foods in air, water, and soil (Fig. 7) [17].

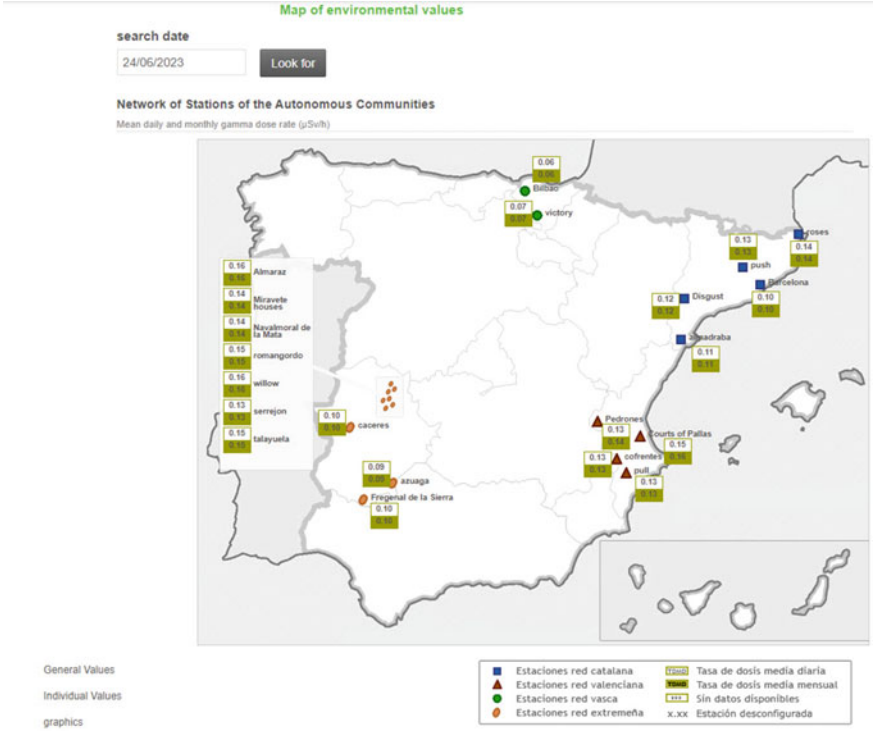

Fig. 7 The radiation monitoring system in Spain [18]

Fig. 8 Automatic station of radiation monitoring [19]

2.5.1 Automatic Stations Network (REA)

The object of this network is radioactive monitoring in the air in real time. Autonomic stations integrate this network with equipment to carry out a continuous measurement of radiological variables (gamma dose index, radon concentration, radioiodines, alpha and beta emitters in the air) and metrological data (temperature, relative humidity, wind direction, and speed, amount precipitation, and atmospheric pressure) (Fig. 8).

The data generated by this network is analyzed at CSN Salem. CSN Salem also has access to data from regional networks in Valencia, Extremadura, Catalonia, and the Basque country. Radiological monitoring with automatic stations is completed at receiving data for CSN from almost 1000 stations in the radioactivity warning (RAR) of the Directorate General for civil protection and emergency [17].

2.5.2 Sampling Stations Network (REM)

Unlike REA, surveillance in the network of sampling stations is carried out by taking samples and their subsequent radiological analysis.

REM is composed of two complementary networks: the dense network, with numerous points distributed around the territory, and the high sensibility of the

network, where measuring is done in very few moments. Both networks carry out measures corresponding to two types of programs [17]:

- Program of the atmosphere and terrestrial-monitoring to measure radioactive in soil, air, drinking water, milk, and standard diet. CSN implemented this system with the cooperation of a series of laboratories and institutions all over the country.
- Program of the coastal and continental water environment to inspect the radiological quality of rain waters in the various river basins and ocean water at multiple points of the cost. This program is performed by the Center for Research and Experimentation of Civil Work (CEDEX) in cooperation with CSN.

2.6 Sweden

The Swedish Radiation Safety Authority (SSM) manages two telemetric networks for monitoring external gamma dose rates. A nationwide network consisting of 28 monitoring stations (Fig. 9) and a network comprised of 30 monitoring stations near nuclear power plants (Fig. 10) [20].

The monitoring stations operate autonomously and transmit data continuously to the network servers SSM. SSM manages the monitoring stations via special software and ensures supporting operations through collaboration with the administration in the NPP.

The prim y purpose of the nationwide network is to alarm if there is a significant increase above the natural background gamma radiation level and provide an

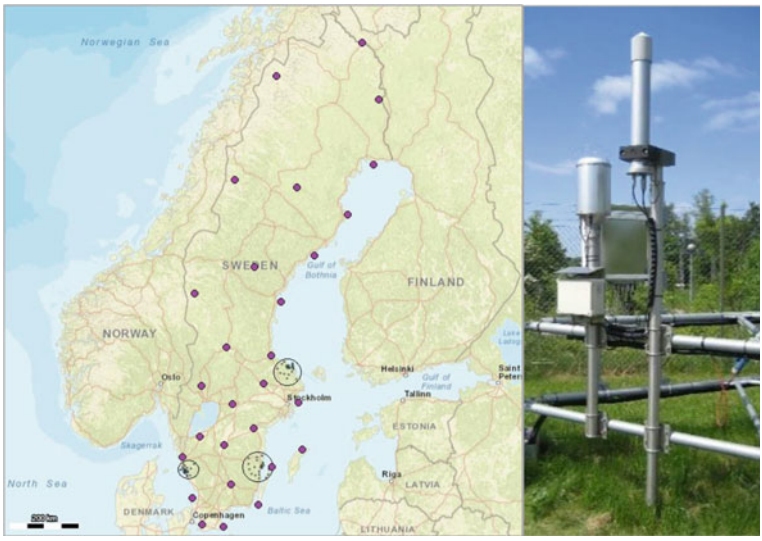

Fig. 9 Location of the nationwide network of monitoring stations

Fig. 10 Location monitoring stations near NPP

instant overall picture of the radiation situation in Sweden. In addition, the purpose of monitoring networks NPP is to give an early indication of gamma radiation levels and plume direction following a nuclear accident with the release of radioactivity to the environment.

Both networks monitor ambient dose equivalent rate using monitoring probes equipped with three compensated Geiger-Muller tubes, enabling a measuring range of 10 nSv/h–10 Sv/h for every monitoring station.

All monitoring stations use GammaTRACER XL2-3 (Bertin GmbH12, Germany) as a measuring device. The monitoring probes of the nationwide network are mounted on metrological stations, which are managed by Swedish Metrological and Hydrological Institute [21].

2.7 Czech Republic

The environment radiation monitoring is carried out at a territory network and a location network on the territory of the Czech Republic that has appropriate licenses [22]. For example, Fig. 11 shows the network of radiology monitoring in the district of location Dukovany NPP.

2.7.1 Network of Integral Measurement

A total of 180 current measuring points are operated in the territorial network, and 123 current measuring points are used in the local network in emergency planning zones of a nuclear installation. Thermoluminescent dosimeters are located at the

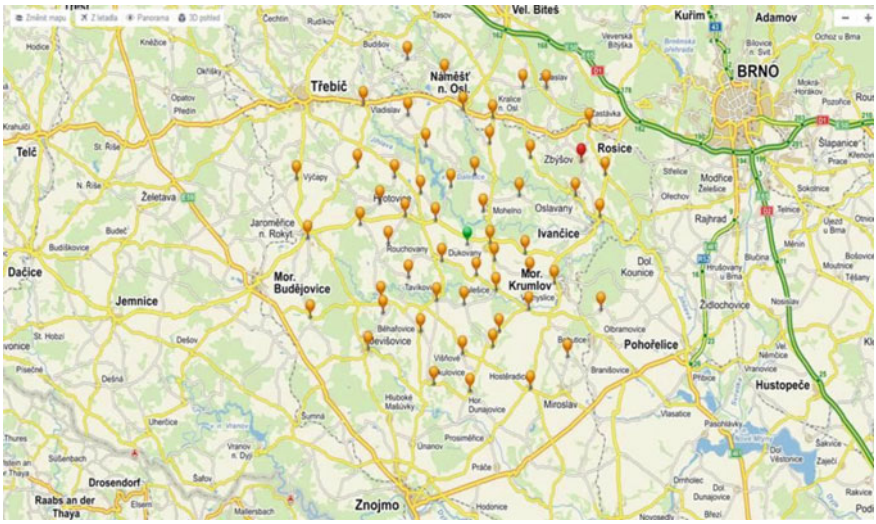

Fig. 11 Location of the measuring points with radiation monitoring near Dukovany NPP [23]

measuring site for three months, and after, they are evaluated in the measurement laboratory. After evaluation every quarter, those data are transmitted to the Data Center [22].

2.7.2 Network of Monitoring Routes

The 25 mobile groups for ground monitoring and two air groups for aerial monitoring are involved in the network. The mobile groups transmitted data to the Data Center from the monitoring routes of ground monitoring once a month in the form of a file to be uploaded by the mobile groups through the web interface in the specified format. In addition, the air groups perform a drill twice a year and transmit data in the prescribed form [22].

2.8 Germany

The German nationwide monitoring network (ADER) includes ~1800 stationary probes equally distributed over the German territory with a typical distance of 20 km between them (Fig. 12). Their density is increased in the 25 km emergency planning zone around NPP. These additional probes are installed and operated by complementary networks from federal states. Data are exchanged between das Bundesamt für Strahlenschutz (BfS) and the local government and are carried out on a bilateral

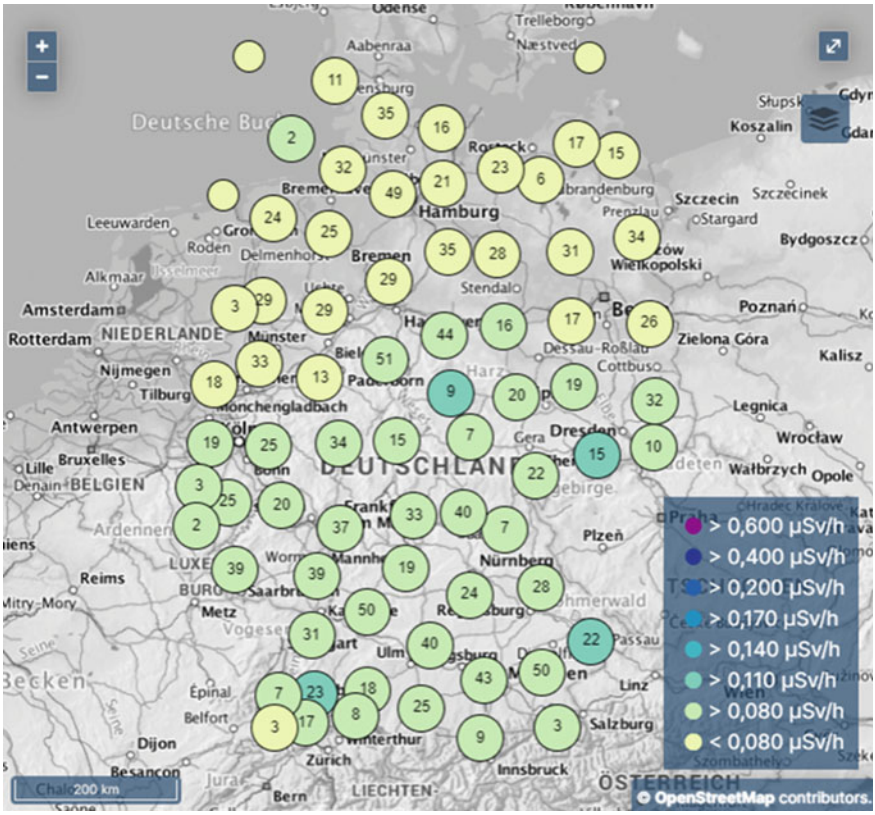

Fig. 12 Probes' location of radiation monitoring network [25]

agreement. In the emergency regimen, data from all stations can be accessed almost in real time, enabling the population's information to be efficient and prompt [24].

The monitoring network is a part of the German «Integrated Measuring and Information System for the Surveillance of Environmental Radioactivity» (IMIS) and German national response plan, which considered the consequences of large-scale radioactive pollution of the environment. Moreover, data was transmitted to the European radiological data exchange platform (EURDEP) to aggregate a complete picture of European persons who accept decisions [26].

Ideally, monitoring stations ADER should be located on extensive flat grassland on undisturbed natural ground. In practice, two rules are used for the selection of new places for the installation of detectors. Firstly, probes must be installed at a height of 1 m on the flat natural ground (grassland) without disturbing buildings at a distance of 20 m. Secondly, considering neighboring stations, necessarily choose aimed at an almost homogeneous coverage of the German territory [26].

2.9 Switzerland

National Emergency Operations Centre (NEOC) has its radioactivity monitoring network–NADAM. It consists of 76 stations, placed on the metrological stations MeteoSwiss in all territory of Switzerland (Fig. 13), that transmitted the measured values at ten-minute intervals to the NEOC [27].

If the threshold value excessed 1000 nSv/h, an alarm is automatically raised. Depending on locations, the average daily values veer from 80 to 260 nSv/h. This is generally due to differences in the level of natural radiation.

At all stations NADAM, the part of artificial radiation amounts to only a few percent. The fake part mainly comes from the Chornobyl reactor accident in 1986 and the nuclear weapons test in the 1960s. The beginning of rain can lead to a temporary increase in the measurement values due to the natural radioactivity being rinsed from the air. The precipitation intensity and duration of the previous dry period are decisive here. In winter, the snow cover can decrease the part of ground radiation to such an extent that the measured values are below those observed in the long term [27].

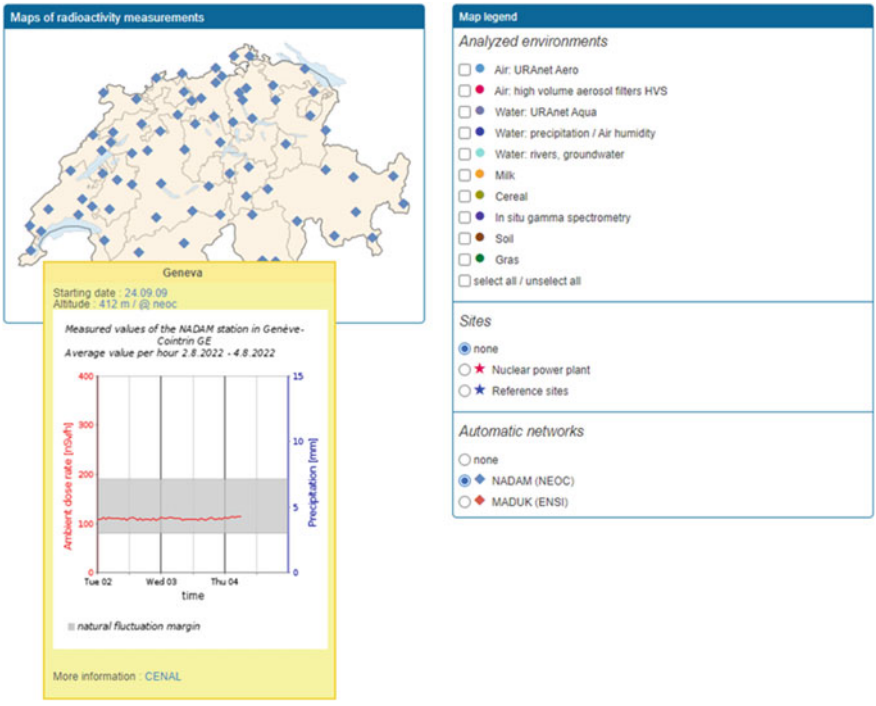

Fig. 13 Swiss radiation monitoring system [28]

2.10 The UK

After the Chornobyl Nuclear Power Plant (1986) in 1988 was installed, the nuclear radiation monitoring and accident response system (RIMNET) was to monitor the consequences for the UK of nuclear incidents abroad. To the present, this system operates on the territory of the UK [29].

Radiation dose rate indications (gamma and cosmic) of 96 sites around the UK are collected every hour and checked for any sign of abnormal increase (Fig. 14) [30].

Background radiation continues to be the main component of observed levels of gamma radiation recorded at RIMNET sites. The monitored UK annual radiation dose rate ranges from around 0.5 to 1.0 mSv with an average of less than 0.7 mSv [29].

The site's geology is the main factor that influences the monitored radiation dose rate. For example, higher levels are found in igneous rocks with relatively high uranium and thorium contents, while lower levels are typical of clay and chalk areas.

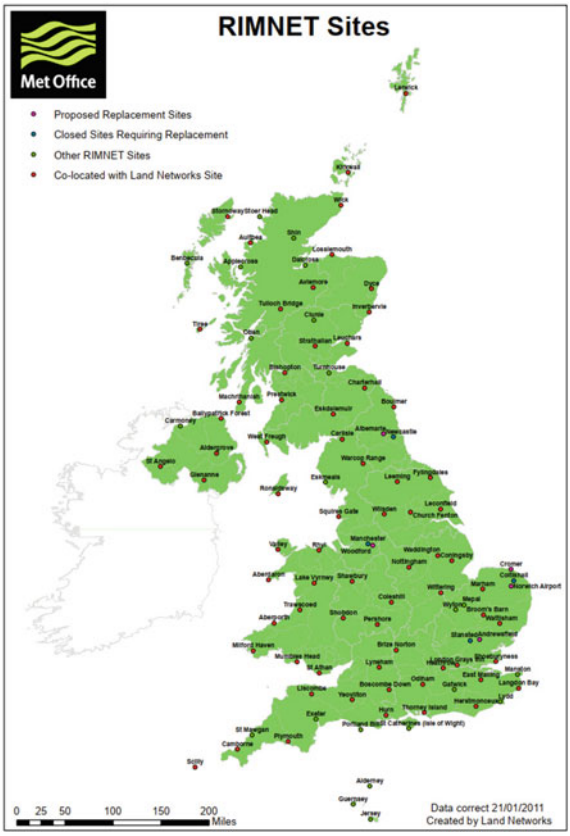

Fig. 14 Location measurement points RIMNET

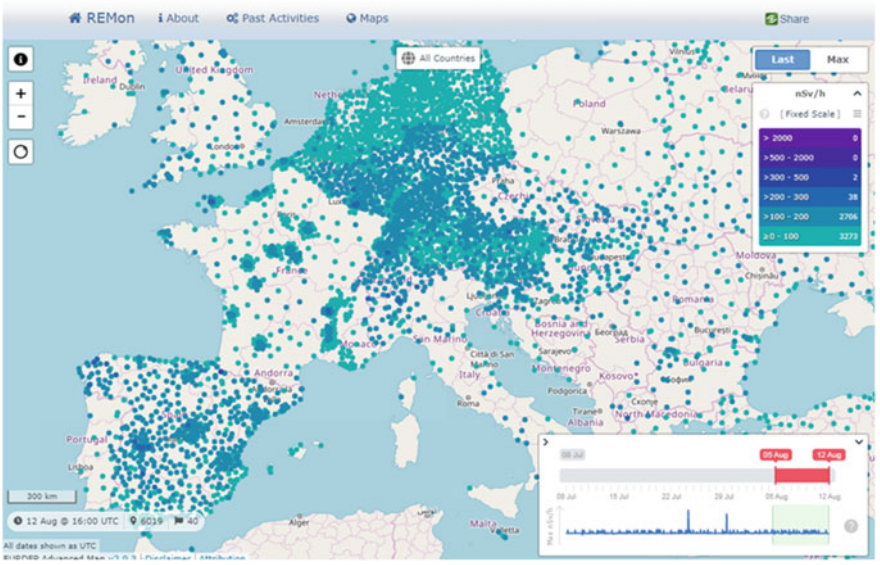

Fig. 15 European radiological data exchange platform (https://remap.jrc.ec.europa.eu/Advanced.aspx)

In addition, the pattern is affected by height above sea level and climatic effects; for example, heavy rain can cause increased levels of gamma dose rate owing to the wash-out of radioactive daughter products from the decay of naturally occurring radon [29].

Worthy of attention European Radiological Data Exchange Platform (EURDEP) consists of a data exchange mechanism and presentation website for radiological monitoring data (Fig. 15). Those data were collected and distributed by 39 countries in almost real-time. EURDEP is the EU's official tool for exchanging radiological data during an emergency. Still, data is exchanged constantly and automatically. It is available at all times, and an additional efforts can be minimized in case of a crisis. During normal (non-emergency) times, the data collected reflects the current natural radiation background. EURDEP is not a fast alert system. The early notification of a radiological accident or emergency is carried out through the European Community Urgent Radiological Information Exchange system (ECURIE), which the European Commission operates 24/7 [31].

2.11 South Korea

The country operates 25 nuclear power reactors, a nuclear research reactor, nuclear fuel fabrication facilities, and radioactive waste disposal facility. Korean Institute of Nuclear Safety (KINS) is the only atomic safety regulatory expert organization that

protects the public and the environment from the harmful effects of radiation. KINS, on behalf of the Korean government, conducted radiation monitoring around nuclear facilities and analyzed the relevant samples. Furthermore, local government around nuclear facilities have operated their radiation monitoring system [32].

The received information about radioactivity is open to the public via the Integrated Network of radiation monitoring of the environment (IERNet) (Fig. 16) [33].

KINS introduced a mobile monitoring system mounted on vehicles to compensate for the mobility limitations of a fixed monitoring post. Monitoring systems monitor the surrounding areas where nuclear installations are located. That monitoring system can be used to monitor the radioactive plume formed during emergencies of various origins during the operation of these installations. The local government constantly compares the received data for reliability with the results of KINS. All local governments on the territory of which NPPs are located carry out weekly radiation monitoring using a mobile monitoring system. The resulting data are open to the public and are provided as core data for plans for identifying environmental radiation across the nation (SIREN).

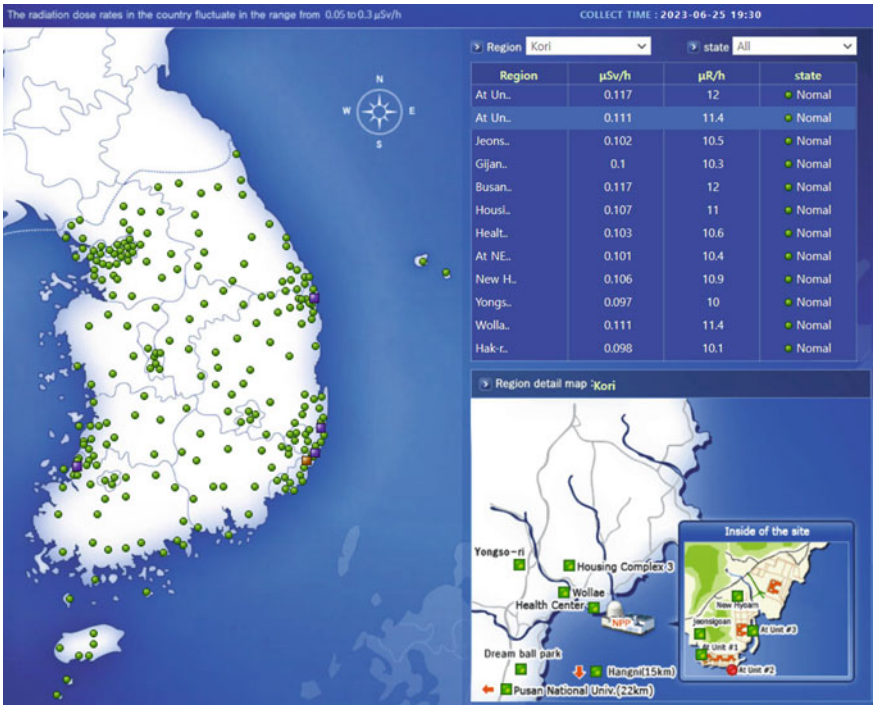

Fig. 16 Integrated network of radiation monitoring of the environment [33]

2.12 Canada

Canadian radiological monitoring network (CRMN) – is a specialized radiation monitoring network that r routinely monitors radioactivity in the environment. It detects natural and technogenic radiation, including downstream products such as drinking water and food [34].

CRMN has been in operation since 1959 and currently includes 26 monitoring stations across the country (Fig. 17). The data from these stations has helped to establish long-term trends in radioactivity from natural contributions and identified radioactivity generation by human activities like historical fallout, nuclear power generation, medical isotope production and international nuclear or radiological incidents [34].

Health Canada's radiation surveillance division (RSD) monitors, detects, and assesses environmental radiation in Canada and internationally. This division uses specialized expertise, laboratories, and three specialized networks of radiation monitoring stations at over 100 locations across Canada. This provides the government of Canada with a basis for radiation risk assessment and management that also enables the identification of nuclear events.

Canadian radiation monitoring networks run 24 h per day, seven days per week.

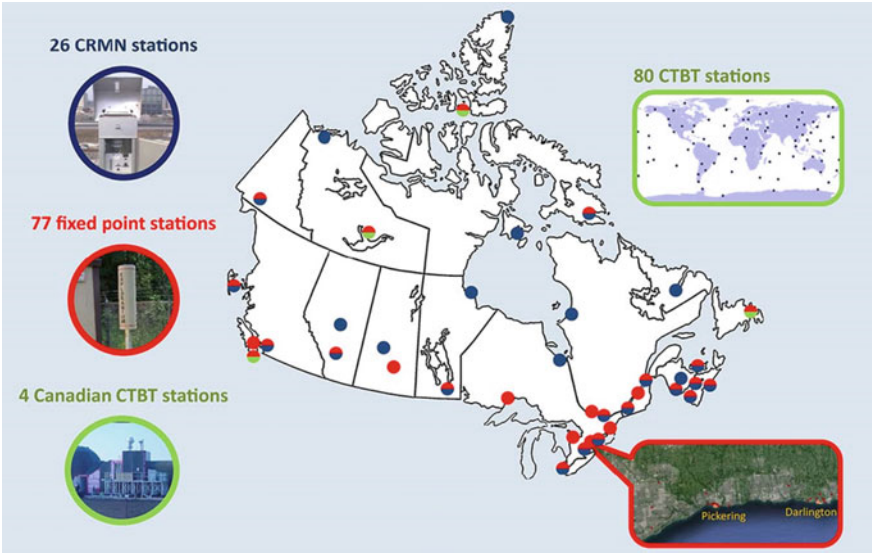

Fig. 17 Radiation monitoring network [35]

2.13 Japan

Japan carries out environmental radiation monitoring within the prefecture. Every prefecture implements monitoring and transmits data to the central government. After the Fukushima NPP accident was added, over 4000 monitoring posts were across Japanese territory. Expect stationary observation posts in Fukushima prefecture using the radiation map of Kyoto University (KURAMA), which considers cosmic radiation. KURAMA map use data received from scintillation detectors NaI or CsI. Information about gamma radiation dose rate and corresponding coordination are recorded and transmitted to the central government [36].

Fukui Prefecture and nuclear facilities have set up monitoring stations (points) to measure nature radiation and confirm the safety of the nuclear facilities. The monitoring stations are located near five nuclear facilities in the Fukui Prefecture. For the daily monitoring, 44 stations in Fukui Prefecture, 62 stations by nuclear facilities operators and 11 nations posts for the environment radioactivity level monitoring of the Nuclear Regulation Authority (NRA). Therefore, for an emergency is possible to use close pact monitoring centers in Fukui Prefecture [37].

All information about air pollution levels of chemical and radioactive substances in Japan can see on the website: https://map.safecast.org (Fig. 18).

Scientific research institute of nuclear science has a few monitoring posts and stations in the Tokai region and surrounding it, with the help of continuous monitoring of the radiation dose rate and the concentration of radioactivity in the air. These monitoring and metrological are collected using the measuring equipment of the environmental radiation monitoring system (Fig. 19).

2.14 China

Mainland China is building and exploiting 56 nuclear power units as of 31 March 2022; 38 of them are operating units (Fig. 20). All data about NPP and environmental radiation monitoring can receive at the website http://spi.mee.gov.cn:8080/spi.

Information about environmental radiation monitoring network operations in Hong Kong can receive at the website https://www.hko.gov.hk/en/publica/pubrm.htm.

The central attention to environmental radiation monitoring in Hong Kong concentrated on all ecological components. Also, this system finds out artificial radioactive materials in the environmental samples in Hong Kong and foods consumed by residents. A place for measuring the radiation level in real-time is shown in Fig. 21. Other locations for ambient gamma radiation measurement and environmental sampling in 2021 are shown in Fig. 22 [39].

The radiation monitoring network (RMN) of the Hong Kong Observatory consists of 12 monitoring stations (Fig. 21). The network provides complete coverage for

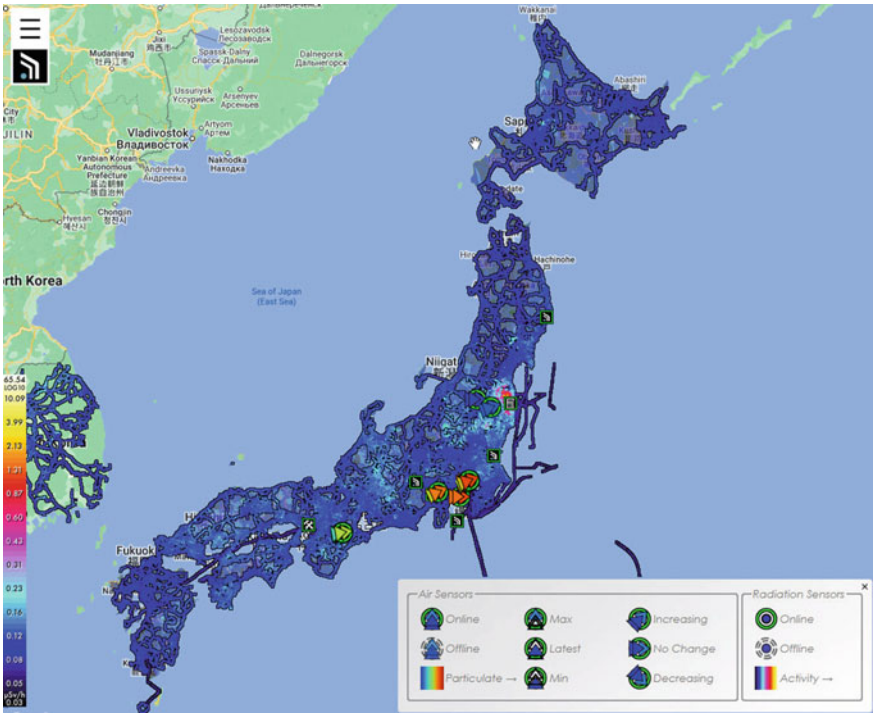

Fig. 18 Air pollution monitoring network safecast map

measuring ambient gamma radiation levels in Hong Kong. The dose rate is calculated at each station continuously using a High-Pressure Ionization Chamber (HPIC). Minute-by-minute data is transmitted to observatory headquarters through a dedicated government communications network and other data channels. New HPIC models (Reuter-Stokes RS-S131-200) were implemented at ten monitoring stations in 2021. In addition, data on the average hourly power of the ambient dose of gamma radiation that radiation monitoring stations obtain are available on the Internet for public review.

The online gamma spectroscopic analyzer network (OGSAN) began its entire operation in 2018, with online gamma spectroscopic analyzers installed at eight designated radiation monitoring stations. The gamma spectroscopic analyzer (RS250 Gamma Monitoring System) uses a sodium iodide (NaI) detector for environmental monitoring.

The thermoluminescent dosimeters network (TLD) has been operating since the late 1980s to measure gamma radiation doses accumulated over time. The network included 29 stationary monitoring stations on the territory in 2021 (Fig. 22).

The Hong Kong Observatory began airborne radiation monitoring in 1998 and replaced the monitoring system in 2013. The modern air radiation monitoring system *(ARMS)* consists of four 2.5-L sodium iodide (NaI) detectors that can be mounted

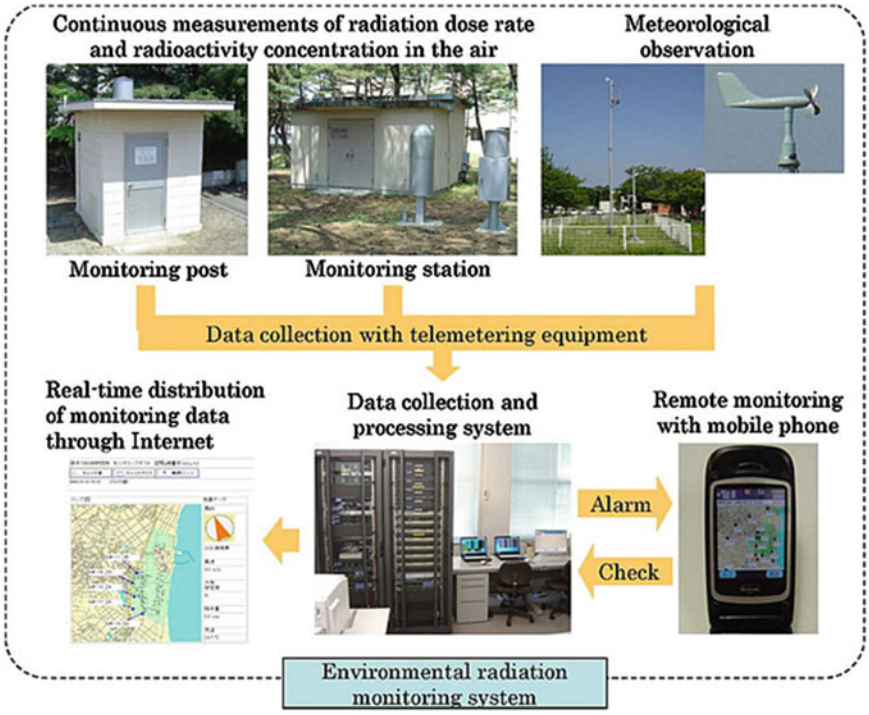

Fig. 19 The radiation monitoring system in the Tokai region [38]

aboard a civil aviation service helicopter. ARMS can operate in plume tracking mode, determining the existence and extent of any radioactive plume over Hong Kong. After passing via the plume, the system which works in the way of measuring soil contamination can be used to identify areas of the surface contaminated with radionuclides. Information about location in real-time, gamma spectra, spectroscopic analysis results, gamma radiation dose rate, etc., are displayed on board the helicopter during monitoring. The advantage of ARMS vis that it can be used to determine radiation levels in remote areas and regions inaccessible to ground transportation.

The Hong Kong Observatory has been operating the automated gamma-ray spectrometry system *(AGSS)* in Ping Chau since 1996 (Fig. 21) to warn early of any technogenic radionuclide releases from the NPP. Currently, the system consists of an ion-implanted silicon detector, high-purity germanium (HPGe), and a NaI detector.

Currently, the observatory has two devices for radiation monitoring of the Earth. A mobile radiation monitoring station *(MRMS)* is installed inside each inspection vehicle. It is equipped with portable and custom-made instruments during specimen collection and routine and emergency radiological examinations.

Fig. 20 Information about the Chinese NPP location

Fig. 21 Radiation monitoring network that operates in real time [40]

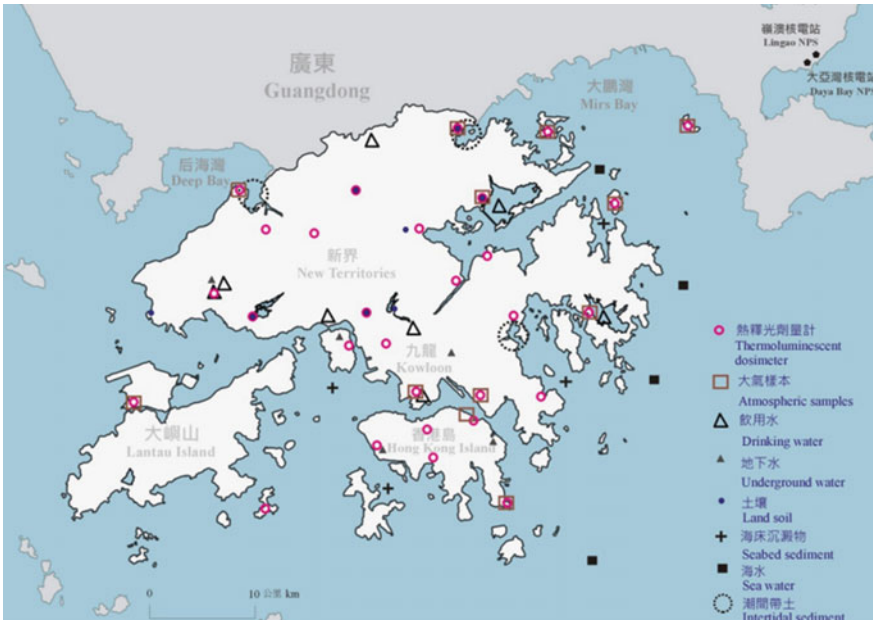

Fig. 22 The thermoluminescent dosimeters network and environmental sampling points in 2021 [40]

2.15 Russian Federation

The unified state automated system for monitoring the radiation situation on the territory of the Russian Federation (EGASMRO) is intended for informational support of the activities of state authorities and management at all levels to ensure radiation safety on the territory of the Russian Federation (Fig. 23) EGASMRO combines departmental and territorial radiation monitoring systems into a single system. The Basic territorial subsystem of radiation monitoring (BTORM) of Rushydromet as part of EGASNRO provides constant monitoring of the radiation situation on the country's territory. BTORM is intended for continuous monitoring of radioactive contamination of components of the environment, collection and processing, presentation of information about the radiation situation and its assessment and forecast, control of transboundary transfer of radioactive substances, information support for decision-making regarding the power of the radiation situation and ensuring radiation safety [41].

Around all plants and other nuclear radiation hazardous enterprises of Rosatom have automated systems monitoring the radiation situation (ASMRO). Dozens of sensors are located in the territory of the sanitary protection zone and the observation zone with a radius of up to 30 km or more around the station. Operational information about the radiation situation near Russian nuclear power plants and other facilities

Fig. 23 Radiation situation in the territory of the Russian Federation [42]

of the nuclear fuel cycle of the atomic industry is presented on the website www.rusianatom.ru.

3 Conclusions

One of the main aspects of nuclear and radiation safety is radiation monitoring in the territories where hazardous radiation facilities are located, which various legal acts regulate.

As a result of a critical analysis of the functioning of the radiation monitoring systems of various countries of the world, namely Ukraine, the USA, India, France, Spain, Sweden, The Czech Republic, Germany, Switzerland, the UK, South Korea, Canada, Japan, China, and the Russian Federation, it is shown that each system has: its construction features; different density of location of stationary monitoring posts; different number of mobile control posts performing a set of measurement in the scope of fixed control posts; various equipment for measuring radiation pollution in environmental components; differences in transmission of received monitoring data through communication channels and analysis and display of these data on electronic maps.

The primary purpose of national radiation monitoring networks is to provide a timely alarm in the event of a significant increase in the level of natural background gamma radiation and provide an instant overall picture of the radiation situation.

The purpose of the NPP monitoring network is to provide an early indication of the levels of gamma radiation and the direction of the plume after a nuclear attack, an accident with the release of radioactivity into the environment. In Emergency

mode, data from all stations can be accessed practically in real-time, which allows for efficient and timely provision of information to the population.

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