Awarding ceremony of 5th IUR V. I. Vernadsky Award
ICRER, Berlin, Germany, September, 2017

60 years of experimental radioecology: working on theoretical and applied problems in the field of radiation safety of the environment

My dear colleagues!

I express my sincere gratitude for the honor of being awarded with the Medal of V.I. Vernadsky. This award is the highest one in the International Union of Radioecology given for scientific input in the field of radioecology. I was fortunate enough to become the fifth winner in the series of predecessors - Ward Whicker (USA), Gennady Polikarpov (Ukraine), Yoshiro Omomo (Japan), Brit Selby (Norway).

I am sure that today a lot of other members of the IUR could have been honored with this Award. I am proud that for 59 years I have been serving this field of knowledge, which is called “radioecology”. V.I. Vernadsky, a great russian scientist, whose name is worn by the IUR medal, was one of the founders of this scientific discipline.

Radioecology originated in the first decade of the 20th century, as a science of the regularities of radionuclides’ migration in the environment and of the effects of ionising radiation on living organisms and ecosystems. The 100-year history of this scientific discipline can be divided into two approximately equal halves. In the first of them, the subject of research was the transport of natural radionuclides (primarily, the uranium and thorium series) along food chains and the influence of the natural background radiation on plant and animal populations. In the second half of the last century, after the discovery of artificial radioactivity, the main focus was shifted to anthropogenic radionuclides in the biosphere. Nuclear weapon tests in the 50-60s of the XX century led to global radioactive contamination of our planet, and this was of a great importance for the further development of radioecology. In the world community, radioecology acquired the status of a branch of knowledge of paramount social importance.

In the 1950s, the term “radioecology” was introduced by a large group of American scientists from the Oak Ridge and Hanford Laboratories, including E.P.Odum and S.I.Auerbach, and scientists from the USSR A.M. Kuzin and A.A. Peredelsky. Vernadsky did not apply the concept of “radioecology”, but rather used “radiogeology”; nevertheless, he often combined two words: "radioactivity" and "biosphere", which is, basically, synonymous with "radioecology".

Two important events happened in 1957, and played an essential role in the development of radioecology. On 29 September, a radiation accident took place in the USSR at Mayak nuclear facility (later called Kyshtym disaster) in the Southern Urals (thermal explosion of a container containing radioactive waste (RW)); on 10 October in the UK in Windscale, a fire occurred on an atomic reactor. In both cases, radionuclides were released into the environment. The 60th anniversary of these events is highlighted in the scientific literature this year.

In 1958, in the area of the Kyshtym disaster at the Mayak facility, a radioecological center was created - an experimental research station that became the alma mater of radioecology in the USSR. There was carried out a unique program of long-term research work on radionuclide migration in natural conditions in different ecosystems, and on the effects of ionizing radiation on biogeocenosis.

The research started in the 1950s on consequences of the global contamination after nuclear weapon tests and of aforementioned radiation accidents, and the study of anthropogenic release of radionuclides to the environment that was continuing within the next 60 years, were named in the radioecology as "experimental radioecology". The period of “experimental radiology” took place from the first International (1966, Stockholm, Sweden) to the second International (2016, Sevilla, Spain) Conferences and received a general title "Radioecological Concentration Processes".

There are segments of economic activity in the nuclear industry that are closely related to the solution of applied radioecological problems. They include:

- radiation accidents with the release of radionuclides into the environment;

- nuclear energy (environmental protection);
- radioactive waste;
- "nuclear legacy".

Prior to the Kyshtym accident in 1957, radioecological studies of radionuclides' migration along food chains had been carried out under control conditions (laboratory and microfield experiments). An important role in the compilation of these data was played by the book by V.M. Klechkovsky (1956) "About the behavior of radioactive fission products in soils, their entry into plants and accumulation in the crop", and a thorough monograph "Radioactivity and Human Diet" written by R.S. Russell in 1966.

Another significant event that greatly influenced on the development of radioecology was the accident at the Chernobyl nuclear power plant in 1986. The period of more than 30 years after the accident was recognized at the international level as a "Chernobyl stage in radioecology".

The word "Chernobyl" became popular not only among nuclear scientists, but also among broad sections of the population. The Chernobyl accident, as well as the Kyshtym accident, was classified as "agrarian" disaster. Radionuclide-containing agricultural products are one of the main sources of public exposure in such conditions. The system of protective measures in the agro-industrial complex was based on the experimental basis of radioecology, and this fact largely predetermined the overall success in overcoming the consequences of the accident.

It should be noted that in the first years after the Chernobyl accident some publications in high-rated scientific journals predicted not only the stagnation of nuclear power, but also the disappearance of radioecology. Fortunately, such predictions did not come true.

A number of applied problems strongly links radioecology with research on the nuclear fuel cycle. At present, we can talk about an independent part of radioecology - "radiation safety of the natural environment". First of all, it should be noted that radiation monitoring is carried out at all stages and enterprises of the nuclear energy's life cycle, describing the migration of radionuclides along food

chains and controlling the maximum permissible emissions of radioactive substances into the environment. The main principles of radiation monitoring are based on the theoretical provisions of radioecology and its experimental basis.

The central problem of the radioecology of nuclear power is radioactive waste management. At present, a new energy program has started developing in Russia, based on the use of fast-neutron reactors and the closure of the nuclear fuel cycle. In the implementation of this program, an important attention is paid to the management of radioactive waste.

There are two methods of handling radioactive waste, aimed at limiting their biological hazard. The first of them is physicochemical and radiochemical. Its main idea is to reduce chemical mobility and bioavailability of radionuclides (inclusion of RW in inert matrices, vitrification, restriction or elimination of RW contacts with biotic components of the environment, etc.). The second method of RW management, nuclear-physical, is more radical, although more complex technologically and, apparently, it has higher economic costs. It suggests to change the radionuclide composition of radioactive waste by transmutation of radionuclides. This ensures a reduction in the volumes of radioactive waste and SNF (spent nuclear fuel), and, most importantly, allows the radionuclide composition of radioactive waste to be changed into a "friendlier composition to the biosphere" (in other words, the most biologically hazardous radionuclides are burned, so the nuclear fuel cycle is closed, including nuclear fuel recycling). It is also rational to consider the question of the combined use of both methods - physicochemical (radiochemical) and nuclear-physical.

One of the basic ideas of the program mentioned above is the principle of handling SNF and RW on the basis of the concept of radiation equivalence in exposure doses for human. These doses are associated, on the one hand, with a certain amount of natural uranium (nuclear fuel), and, on the other hand, with buried radioactive waste generated as a result of energy production using this certain amount of uranium in reactors.

Recently, in a number of countries, including Russia, the so-called "nuclear legacy" has emerged as an independent problem. This is a range of issues, the decision on which was not adopted, although they were classified as sufficiently urgent. Due to lack of financial resources, these problems fell into the category of "postponed". Mainly, these are sites of various sizes with increased content of natural and artificial radionuclides - nuclear test sites, sites for uranium mining, old radioactive waste storage facilities, areas for the disposal of decommissioned nuclear and radiation-hazardous objects (for example, reactors), etc. Reabilitation of these territories requires experimental radioecological research.

As a radioecologist, I was lucky - I took part in elimination of the consequences of the four largest radiation accidents with significant environmental impact. In both Kyshtym (1957) and Chernobyl NPP (1986) disasters I worked in exclusion zones. In case of the accident at NPP "Three Mile Island" (1979) I participated in an international audit of the lawsuit of US citizens for damage to health and damage to the environment (damaged forests). Finally, I worked at Fukushima Daiichi NPP (2011) on scientific consultations with entering to the accident zone.

In these brief materials, I made a modest attempt to describe the history of events related to the development of radioecological research. In all these events, where I was a participant, my friends and colleagues were active actors. My teachers also were on this way. One of them I can not help but mention - it is a member of All-Union Academy of Agricultural Science Vsevolod Mavrikievich Klechkovsky, an outstanding radioecologist, a prominent agronomist. I would like to note that on my whole creative path I have been under the beneficial influence of the nuclear industry organizations (now the State Corporation Rosatom), and the Academy of Sciences of the USSR, and the Russian Academy of Sciences. I express my sincere gratitude to all of them.

Radioecology is a deeply international scientific branch, and IUR is a member of the family of such organizations as IAEA, UNSCEAR, ICRP. I am

absolutely convinced that radioecologists have yet to accomplish many glorious deeds!

Today, the main tasks of radioecology are aimed at solving urgent issues of ensuring radiation safety of the natural environment in the dynamic conditions of enhanced development of innovative technologies.

Once again, let me thank you all for your benevolent attitude.

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