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Chernobyl and Fukushima nuclear accidents: What have we learned and what have we done?

Nuklearni akcidenti u Černobilju i Fukušimi: šta smo naučili, a šta učinili?

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Introduction

Construction of new blocks of the Nuclear Power Plant (NPP) PAKS 2 in Hungary last few months caused vigorous debate in the media. Most of the titles, as always when it comes to radiation, is sensationalistic and encourages fear and concern of the Serbian population because of the proximity of a nuclear installations to our border. As the professional community does not sound a lot, spreading of fear is undisturbed.

The exploitation of nuclear energy and the accelerated construction of NPPs began with the assertion that this is, unlike thermal power plants, environmentally clean, safe and secure energy production. However, reality shows that every ten years at least one large-scale nuclear accident happens, called major nuclear accident, which can endanger people and the environment. Currently there are over 440 NPPs operating in the world. None of them is in Serbia [1].

This spring marks the 30th anniversary of the accident in the Chernobyl NPP, one of the largest in the history of the application of nuclear energy and 5 years from the accident at the Fukushima Daiichi NPP, which was just by chance not overcome by the harmful effects. Although geographically distant, these events had a profound influence on Serbia and entire European continent, not only by harmful effects on the health of the population and the environment, but also influenced public opinion and attitude towards nuclear energy as well as the defence and response organization in the event of accident. It became definitely clear that accidents of this type, which are not limited by political and national borders, can only be tackled through joint and synchronized activities. This attitude has led to the launch of a number of joint activities under the auspices of international organizations (United nation – UN, the World Health Organization WHO, International Atomic Energy Agency – IAEA): education, synchronization, joint team creation, programs of mutual assistance and notification, mutual long-term monitoring of late effects.

Each of these accidents was analyzed in all respects to observe the slightest flaw and find solutions to overcome the observed and the prevention of recurrence of error. In most countries such accident was the cause to review their response plans in case of accident, and improve them by incorporating new knowledge. As members of the Team for response in the event of radiation accidents and consequence monitoring, we wanted to remind of both Chernobyl and Fukushima Daiichi accident.

The aim is to analyze preparedness of our country for the event of a new nuclear accident and whether we have reason for concern about the construction of new reactors in the NPP Paks 2 in Hungary.

Chernobyl vs Fukushima Daiichi accident

It was written a lot about Chernobyl accident in previous years, so we will look back at it only through important

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facts and for the purpose of comparison with other accident. Chernobyl accident happened on April 26th, 1986 as a consequence of two subsequent explosions in one of four nuclear reactors of the Chernobyl NPP (Unit 4). Explosions were caused by a few factors, but mostly by manmade mistakes and some technical imperfections. They caused large radioactive release in a very short time. Additionally, high temperatures in the reactor caused further melting of the remaining fuel, which caused prolonged radioactive emission for the next thirty days. It is estimated that the total amount of radioactive release was 5,300 PBq, 200 hundred times higher than radioactivity used on Hiroshima [2, 3]. Radioactive cloud released at the time of explosion (450 PBq) was expelled 9 km high in the atmosphere, and later on carried by the winds over many European countries, first over Scandinavian countries, then changing direction of the air currents contaminated Poland, Czechoslovakia, southern parts of Germany, Austria, and finally South and Southeast winds accompanied by rain showers have led to contamination of Balkan countries. Most of the radioactive fallout was dispersed over Belarus, Ukraine and Russia [4, 5].

During the first three days of the accident iodine-131 (I-131) was the most dangerous for the health of residents of contaminated areas, and then dominated cesium-137 (Cs-137) and strontium-90 (Sr-90), and to a lesser extent, plutonium-241 (Pu-241) [6]. In addition to these radioactive elements, "hot particles" were found in the cloud, which had the same composition as irradiated nuclear fuel from the damaged reactor. From the very beginning Chernobyl accident was proclaimed as Major accident, according to the International Nuclear Events Scale (INES) level 7 event, which is the largest-scale accident, which endangers the environment and population. Employees of the NPP, as well as rescue teams, mainly firefighters, soldiers and medical teams with superhuman efforts and numerous human sacrifices did everything to prevent the worst. Estimated by expert commissions, Chernobyl accident, regardless numerous causes, was primarily the result of human error. The accident of such large scale was not even considered in the document for the risk assessment and plans for the Chernobyl NPP emergencies [6].

On the contrary, Fukushima Daiichi accident did not arise suddenly, but developed over several weeks. This is the accident with highest number of human casualties and destruction and largest in Japan since World War II. At the same time it is a unique blend of natural disasters [7, 8]. Problems on NPP began after the devastating earthquake of magnitude 9 at the moment magnitude scale and tsunami which followed very quickly. Although Japan is a country where earthquakes are not uncommon, this earthquake, whose epicenter was only 180 km from the NPP, for its strength, destructive power and the extent of the territory that was affected, was the fourth measured in the last 60 years. In the affected territory, with 5 NPP, with a total of 15 reactors, of which 11 were in operation, only in the NPP Fukushima Daiichi damage was caused to vital parts, while in the other NPPs damage was caused to the parts of the equipment which were of minor importance [9].

In the NPP Fukushima Daiichi occurred severe core damage in three of the six reactors for which it was announced as the accident INES Level 3 event. At that time (March 12th) most of released materials were radioactive noble gases (xenon-133). At the time of the earthquake there were 6,400 employees in the plant and three days later, after the evacuation and willful abandonment of the NPP, remained about 700. At that time release of hydrogen and radioactive materials occurred and accident announced as INES level 5 event. As a result of earthquake, power supply from external sources was interrupted that caused stoppage of cooling system of the three operational reactors. Generators for emergency situations were later activated, but due to increase of temperature and pressure there were an explosion of released hydrogen and release of radioactive I-131 at the speed of 10^{15} Bq/h and physical damage of three reactor buildings. At that time, INES level 6 event was announced. A fortunate circumstance was that the winds carried the radioactive cloud until March 15 towards the Pacific Ocean. On March 15 wind direction changed and the radioactivity was spilled on land north-west of the NPP, when accident was announced as level 7 INES scale event. Workers of NPP did not succeed in checking the extent of damage to the reactor and generator caused by earthquake, when tsunami came. The main tsunami was 13 m high. After it there was a flood, and a significant part of the plant found itself under water, at some places more than 5 m. That approach was unusable for repairs [1].

The greatest part of radioactivity in the Pacific Ocean was spilled during March and April 2011 through contaminated water that flowed from the NPP and contained radioactive I-131 and Cs-137. That process, to a lesser extent, continued 5 years after the accident [10, 11]. Although three reactors were involved in this accident, the estimated released radioactivity was 520 PBq, or 10% of radioactivity released from the Chernobyl accident. The greatest part of radioactivity was deposited in the Pacific Ocean during March and April that year [3, 11].

Japanese NPP in its Risk Assessment Act had instructions on the procedure in case of earthquake, tsunami or floods, but the intensity of each of the resulting disasters significantly exceeded the maximum assumed value made at the time of its construction. That act has been repeatedly corrected according to the recommendations of meteorological services, and although protective systems have been upgraded in accordance with the recommendations, it turned out that they were not sufficient to defend against each of the disasters occurring individually. The situation in which a NPP is simultaneously affected by three natural disasters was not even presumed in these documents. The defense was further aggravated by disruption of communication and reduction of the number of employees in terms of the increased need [8]. The workers who remained, bearing in mind that many of them received doses that significantly exceeded the permitted levels, showed a remarkable level of consciousness and even sacrificed their own lives. However, in this event a huge number of serious flaws was noticed, misjudgements and decisions, and above all a high degree of improvisation, since there was no plan to respond to that kind of accident. Therefore, the conclusion of the commission that investigated the accident was that it was "manmade disaster – that could and should have been foreseen and prevented". And that was despite the fact that the accident was initiated by disasters [12].

These two accidents have confirmed that each nuclear accident is unique. According to the mechanism different, yet they have a lot of similarities. First among them is that, regardless of the high technology and the number of measures of control and protection, they can never assume the entire unwanted and risky situations. Second, that in such a contingency, regardless of the expertise of the staff and their extraordinary efforts, human error easily occurs.

The consequences of accidents on environment

In both accidents there was a significant irreversible contamination of environment. In case of the Chernobyl accident 150,000 km^2 of the territory of Russia, Belarus and Ukraine were highly contaminated, and therefore evacuated in the radius of 30 km. In the highly contaminated territories of Ukraine and Belarus at the time of the accident lived more than 8 million people, of whom 2 million children. Around 350,000 of them were evacuated or fled their homes. These zones are still largely uninhabited [13, 14].

European continent is less contaminated, but 45,000 km^2 of European countries, including Serbia, have high levels of contamination [5]. Never before in the history of the use of nuclear energy was one territory as contaminated. Taking into account that in addition to I-131 (half-life of 8 days), also present are Cs-137 (half-life 30 years) and Sr-90 (half-life 28 years), contamination of the territory can be considered long-term. According to the experts of Greenpeace, because of the high contamination of long-lived transuranic radionuclides, a radius of 10 km around the NPP will not be ready for the return of residents for tens of thousands of years.

People who live in the contaminated terrain are confronted with everyday problems of contaminated food and water. Cs and Sr enter the food chain mimicking their physiological analogues potassium and calcium thus contributing to the overall contamination of the living world. Over the past three decades, residents of border regions which are not displaced have limited the intake of radioactive substances in different ways, limiting dose, using foods that are not grown on contaminated territory, regime of diet in accordance with the level of contamination of certain foods (ETHOS project), etc. Today, 30 years later, there are no social benefits as in former years. People are forced to feed on agricultural products grown in the contaminated territories and feel abandoned and sacrificed from the society [1, 15].

Although the values of Cs and Sr in the environment have been reduced by half, there are areas where they are still high, such as forests and humid parts of the wetland (over 30% of the territory). Forests are a kind of reservoir of contamination because they cannot be decontaminated and can scatter contamination in different ways. Inhabitants of these regions use natural products (mushrooms, forest fruits blueberries, venison and fish) daily, significantly raising their radioactivity intake. Cs-137 level of mushrooms samples is 16 times higher than allowed. Samples of milk used for children nutrition few hundred kilometers away from Chernobyl contain levels of Cs-137 significantly exceeding set limit values. Feeding cows with rotten grass from wet terrain which contains elevated concentrations of radioactive material, increases contamination of milk that directly endangers children. The main problem is the control of foodstuffs. Those sold in shops are controlled by state laboratories, but food sold "on the street" nobody controls. Lack of financial resources for the organization and implementation of large-scale monitoring is an essential problem of establishing control [1].

A special type of population exposure comes from forest wood used for heating. The ash created by burning wood is used for spreading on arable land, and contains twenty times more Sr-90 than timber sample. This further contaminates agricultural land, and indirectly, all agricultural products that are grown on these plots. In conditions of incurred contamination when no one controls the forests they represent a big risk because of the possibility of the occurrence of forest fires. In the period after the accident over 1,000 forest fires were formed. The resulting ash and smoke contain radionuclides which increase air pollution [1].

In case of Fukushima Daiichi accident a lucky circumstance was that most of the radioactive material, as much as 80%, was deposited in the Pacific Ocean. In Fukushima accident 140,000 residents have been evacuated: 78,000 were instantly evacuated from the immediate area surrounding the NPP, and later 62,000 from zones that were subsequently contaminated by radioactive cloud [8]. Contamination control of water, milk and food was immediately organized. In the first days after the accident leading contaminant in food and water was I-131, so the iodine prophylaxis was recommended. Although there was sufficient provision, distribution and the beginning of prophylaxis were late and have started on the fourth day, when majority of inhabitants of the contaminated territory have already been evacuated [16, 17]. As in the case of the Chernobyl accident, these zones are uninhabited and thus should stay for a long time [18].

A few days after the accident the direction of the air current changed so that about 20% of the released radioactivity contaminated terrestrial territories of Japan northwest of the NPP, which is much smaller contaminated area than in the Chernobyl accident. These areas are mountain forested landscapes that are not densely populated, houses are scattered and often surrounded by forest. The inhabitants of these regions, 62,000 of them were evacuated during the accident and the majority is still in temporary accommodation with regular social benefits from the government of Japan [19]. Evacuation of the population was not well organized, reported even as chaotic. Residents were relocated several times from place to place, they often rejected transfer, and transportation of immobile patients and old people was not well organized. Many old and immobile remained on contaminated ground. All this has led to a loss of confidence in the authorities of Japan and new actions [20]. In the same way as in the vicinity of Chernobyl residents can be further contaminated. Unlike Chernobyl accident when Soviet government delayed ban on the consumption of food, the Japanese government immediately banned the use of all foods from this area and provided financial compensation [6, 21].

The level of contamination is still high and the inhabitants of these villages, including children, could receive annual doses of 20 mSv/y, which is the limit for occupationally exposed persons by international standards. It is significantly higher than the dose for the members of the public in non-accidental situations (1 mSv/y), and the dose in the Belarusian villages (5 mSv/y). In spite of that, Japan government made decision to apply the limit for occupationally exposed persons on occupants of this area starting from 2018, when it will abolish all social benefits to displaced persons. The decision was made because the government cannot finance decontamination of this area which is roughly estimated to more than 50 billion USD. Therefore, around 55,000 residents would be forced to return to their contaminated homes. This risk is considered to be unacceptable, especially for children [22].

From both cases it can be concluded that the contaminated territories remain unusable for people because of their direct impact on health and impossibility to produce basic crops. Evacuation of the population due to contamination represents economic and social collapse of the region. Decontamination, monitoring and regular controls are extremely expensive and, as they should be organized tens, even hundreds of years, not economically feasible. These costs cannot be beared by countries of less economic power (Ukraine and Belarus), nor could be by economically the most powerful country in the world (Japan). Attitudes of state institutions on these issues are often contradictory to attitudes of independent professional organizations.

Health effects

There is a lot about health effects that we still do not know. However, it is certain that there is no unified position on the extent and type of health effects, primarily due to our incomplete knowledge of low-level dose effects. It is almost certain that we will never know all about them, because of lack of the dosimetry results and accurate epidemiological data which are necessary to make a judgment.

Acute health effects

During the Chernobyl accident the most exposed was personnel of the NPP and rescuers (firefighters, army and medical personnel). Over 1,000 people have been engaged at the NPP but they neither possessed equipment for dosimetry, nor for personal dosimetry in accidental conditions. Fire and medical teams found themselves on the spot after 15 min. As the dose in the control room were several hundred Gy/h, and at the facility over 100 Gy/h, people involved were exposed to huge doses, and due to acute radiation syndrome first patients were hospitalized during the first hour. Local doses were up to 20 times higher. According to official reports during the first 12 hours 132 people were hospitalized. With the suspicion of acute radiation illness 273 people were hospitalized, while the diagnosis was confirmed in 132, and 28 workers had lethal ending [23]. Extraordinary efforts and the introduction of innovations in the diagnosis and therapy of acute radiation illness ("heroic therapy") half lethal dose (LD-50) increased from 3.25 Gy to 10 Gy. In June 1986 specialized hospitals in Moscow, Minsk and Kiev were established for the treatment of the Chernobyl accident victims [5]. It must be pointed out that there are indications and some authors claim that the number of injuries in the acute phase was several times higher than indicated in the official reports [24].

Among the residents of the nearest town of Pripyat there were no cases of acute radiation illness. However, the doses were high, even 1,000 times higher than natural. At the night of the accident 40,000 residents were evacuated in only 3 h from the circle of 10 km and a few days after 150,000 residents from the circle of 30 km. Prophylactic distribution of potassium iodide was organized for the residents of Pripyat within 12 h, but it was not organized for the residents of the wider circle of the contaminated zone, which is considered one of the greatest failures of the health system during the accident [15, 24, 25].

Residents support by health services consisted of 2,000 physicians, 4,000 technicians, and 1,200 final year medical students. They did more than 600,000 examinations, 215,300 on children, a huge number of laboratory analyzes (radiometric, biochemical, hematological, immunological and cytogenetic) [15, 26].

Fukushima Daiichi accident was induced by natural disasters, earthquake and tsunami that brought widespread destruction of material goods (losses exceeding $ 200 billion) and a large number of human casualties (15,900 dead and 2,600 missing). A large number of deaths and injuries had nothing to do with radioactive contamination that followed [1].

As already mentioned, the evacuation and care were not satisfactory, which can be explained by devastation caused by natural disasters. In ordinary situations, Japan is a country with an extremely organized radiation medicine, so that person injured in a radiation accident can be transported to a specialized institution within two hours.

Long-term health effects

Long-term effects of Chernobyl accident are the main point of controversy for 30 years. They should be expected in workers exposed to high doses, as well as inhabitants, no matter if evacuated or left at in their homes in the contaminated area. The fact is that after Chernobyl accident more than 600 million people live in less or more contaminated environment [24]**.** Different ways and time of exposure, dose, dose rate, type of radiation are some of factors influencing onset of late-effects. Radiation-induced late-effects such as malignant diseases, cytogenic changes, and congenital anomalies were in the focus. By time, non-radiation effects came in focus because of their high incidence and their influence on quality of life. At last, social and psychological changes should not be neglected. People evacuated from contaminated zones are higher suicidal, depressive or anxious, abuse alcohol and drugs, have very low birth-rate, etc [1, 24].

Based on Hiroshima victims data, WHO and IAEA estimated that Chernobyl accident could induce additional cancers in exposed population in the next years depending on the latent period – from 5 years (for leukemia) to 30 years (for solid tumors). Registers of Ukraine and Belarus, as well as many authors do not agree with the estimation and point out that the risk is highly underestimated. According to these national Registers general cancer morbidity in most exposed regions of Belarus and Ukraine increased 40% and 22% till 2000, respectively. In both countries a higher increase was in children above 17 years and liquidators [27, 28]. According to these data, additional radiation-induced cancers just in Belarus could be up to 62,500 in the next 70 years [29].

Thyroid cancer is one of the main malignant diseases in Chernobyl victims. It is predominantly, almost always papillary type, very aggressive, fast growing and early metastatic tumor. The highest rate was noticed in children of Belarus 10 years after with 43-fold rate from 1989 to 1994, and 200-fold than before the accident [30]. The increase in thyroid cancer rate has been noticed in contaminated European countries, but in a much lower rate. It is estimated that total number of thyroid cancers could be from 47,000–140,000 cases [29]. Similar situation is noticed with leukemia. After shorter latent period (from few months to 7 years) the incidence increased in all population groups, with the highest rate in children of mostly contaminated regions. The same trend was observed in contaminated European countries (1.5-fold till 1987 in Germany, 2.5-fold in Greece, 37% in Great Britain) [25, 31].

A high radiosensitivity in children is correlated with high incidence of congenital malformations, lower-birth weight, thyroid gland diseases, leukemia, genetic changes. Tne number of healthy children is still decreasing every year [26, 31]**.** The same kind of disturbances, but with lower rate was noticed in many other European countries, such as Finland, Great Britain, Hungary, Turkey, Sweeden) [32, 33] **.**

The increased incidence in morbidity (accelerating age, cardiovascular and respiratory diseases, immunological disorders, diseases of urogenital system, and disturbances of central nervous and musculoskeletal system, cataract, and diseases of the thyroid gland, especially cancer, leukemia) is noticed in adults as well as in children. The incidence rate of these diseases increased 3–4% *per* year, and is higher than before the accident, or in people from uncontaminated zones. Ten years after, 94% of liquidators are not healthy. All the effects mentioned above are dose-depended, and noticed in other species as well, and therefore cannot be attributable to posttraumatic stress disorder (PTSD) or some other psychological disturbance [24].

It is the endless list of diseases and statistics, proving one or another attitude. The fact is that all the risk assessments are connected with some kind of financial compensation, state or political decisions, and above all, global attitude towards nuclear energy. Combined with the lack of date (dosimetric or epidemiological) it is ideal soil for ongoing debates and pro- and contra- controversies. The risk should not be neglected, and follow-up studies and long-term monitoring are necessary.

Serbia

What is the situation in our country? A number of questions are imposed: What are the consequences of the Chernobyl accident in our country today? How much have we learned from the Chernobyl accident? How much have we done to improve protection of our people?

The Chernobyl accident significantly affected the environmental conditions in our country. The territory of the former Yugoslavia was on the path of the radioactive cloud. Unfavorable circumstances were heavy rain showers that have contributed to a significant deposit of radionuclides. Immediately after the accident systematic measurements of environmental samples in our country began. Measurements were performed by laboratories of many relevant institutions. Most laboratories performed gamma-spectrometry measurements by scintillation (NaI) or semiconductor high-purity germaniume (HPGe) counters of high sensitivity [34].

Measurements were carried out on samples of soil, air, water, milk and dairy products, many foodstuffs, as a primary source of contamination for the population at different locations throughout the country. In addition, measurements included the so-called bioindicators of radiation contamination, such as moss, lichen, grass, honey, mushrooms and others. Based on the measurement results, the transfer of radionuclides was estimated in certain areas of soil, to grass, then to milk, and, at the end to man. In the vast majority of the samples elevated levels of I-131 and Cs-137 were detected. Thus, for example, the exposure rate in Belgrade during the accident was elevated 5 times, until the end of the year and remained 2 times higher; in the region of Tara, Zlatibor and Durmitor it was 2–3 times higher [35]. Natural waters (Danube) have also been contaminated, as well as sediments, maintained after the accident for 20 years [36].

During the accident the population was kept informed about the kind of food contaminated. Acute health effects were not noticed except a widespread worry and anxiety about health, especially children. A few years later the increase in the number of hematological malignant diseases, and later on thyroid gland, breast, lung, digestive tract malignancies were noticed. Diseases are diagnosed in younger age and in more aggressive forms than before the Chernobyl accident.

Due to direct impact of I-131 and positive epidemiological data from other regions, special attention is attracted by the increased incidence of thyroid cancer. According to data from Cancer Registry for Serbia the incidence of thyroid carcinoma in Serbia is constantly growing, at a rate faster than for any other malignancy. The most common type is papillary thyroid carcinoma in all age groups and both sexes (more in women than in men 3.3 : 1). Data for Serbia do not differ significantly from those of other European countries [31, 37]. Serbia would be considered as a country with medium rate for women and low rate for men. Particularly disturbing is the fact that the largest increase is among women aged 20–29 years. Iodine deficiency as a possible cause can be excluded, because Serbia is not a region deficient in iodine and has standardized iodination of table salt [38]. The increase incidence of malignant diseases, congenital anomalies, immunological and metabolic disorders was noticed in children.

Serbia has no NPPs, but can be threatened by an accident in a nuclear facility abroad. At 1,000 km from the borders of Serbia there are 21 NPPs with 44 reactors, of which 6

NPPs with 12 reactors at 500 km from the border. The closest NPPs are located in Hungary, Romania, Slovenia and Slovakia. All belong to the older generation NPPs. In case of accidents in these NPPs, and appropriate weather conditions, the territory of Serbia may be contaminated in a few hours. The specific weather conditions can lead to high contamination of the territory of Serbia very quickly.

The NPP PAKS 2 is planned to replace two of the four existing nuclear reactors. Hungarian project is very important for all neighboring countries, especially Serbia, due to its proximity to the Serbian border of about 100 km and the direct connection to Danube. Therefore, it is reasonable to discuss the cross-border environmental pollution and the impact on health of the population. Respecting international regulations the Government of Hungary has sent the Risk Assessment Act to 30 countries for discussion. This document discusses the risk zone of 500 m around the NPP and cross-border risks in the ordinary work of NPP. The act alleged to NPP PAKS 2 will not adversely affect environmental conditions in Serbia: it will not pollute the air (none of the polluters), will not affect the water quality of the Danube (no composition, no temperature), the terrestrial and aquatic wildlife, and the environment of the community. The half of the involved countries had complains and asked for international revision of the Act [39].

Is Serbia ready to react in the case of nuclear accident and potential emergency situations?

Serbia is a signatory to the International Convention on Early Warning of Radiation Accidents and the Convention on Mutual Assistance in case of accident. For early notification on the territory of Serbia a system of 9 fixed stations is organized to measure intensity of ambient equivalent dose of gamma radiation. All data are collected and processed by the Serbian Radiation Protection and Nuclear Safety Agency (SRPNA) to other countries. The National Plan for Response in Case of Radiation Emergency is under jurisdiction of the Agency, too.

The National Plan for Response in Case of Radiation Emergency has been in draft version for several years. A change is needed due to reorganization of the state administration sector, which is transferred from the Ministry of Defence to Ministry of Interior. This service cannot meet all the requirements of an accidental situation due to the lack of material and personal resources and need immediate activity of other relevant services. A whole series of problems showed up, and IAEA has offered help of expert mission that reviewed the plan, facilities, equipment and organization of the whole system planned in the said draft plan. IAEA experts analyzed the draft and pointed out the flaws of the plan with the representatives of relevant institutions.

The crucial part of the National Plan is emergency care and treatment of the injured. This part of the plan is under the jurisdiction of the Ministry of Health. According to the experience of previous nuclear accidents, it would be necessary that the Ministry of Health: make a detailed plan of engagement of medical institutions and a strict division of debts in order to avoid chaotic activity; facilitate the work of emergency teams which, are not equipped, nor trained, for a nuclear accident response; it should organize and provide training and necessary equipment; enable continuous medical assistance to evacuees; establish the conditions and modalities of iodine prophylaxis, from the procurement, storage and distribution of potassium iodide according to defined priorities; develop the guidance on timescales for the application of iodine to current recommendations (a few hours before exposure to 6 h after); to publish detailed instructions for the preparation of doses for children; organize triage and decontamination; ensure continuing education and training for nuclear accident response to all medical staff; take care of food and water- based on the results of measurements to ban or authorize use of water and food.

The very same questions were burning 10 years ago, when we marked 20 years of the Chernobyl accident [40].

Some progress in preparedness for nuclear emergency was accomplished, but unacceptably slowly. A lot of unsolved problems are still to be solved. We hope that lessons learned from previous accidents in NPPs, and construction of new nuclear reactors in front of our doors, will be sufficient impulse for urgent action.

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