

ON THE PUBLIC ACCEPTANCE OF DEEP GEOLOGICAL REPOSITORY DEVELOPMENT IN THE KRASNOYARSK REGION

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The paper considers the issues associated with sustainable public acceptance of an ultra-long-term project on the development of a radioactive waste deep disposal facility in the Krasnoyarsk Region. It discusses the findings of a nationwide online survey focused radioactive waste disposal and the perception of relevant radiation hazards. The paper explores the deep roots causing inadequate public perception of radiation risks, as well as the disappointing results of many-year informative campaigns and the ICRP's enhanced approach to public dialogue as a possible way out of this communication impasse.

Keywords: *final disposal of radioactive waste, deep geological repository, nuclear power plants, public acceptance, online survey, perception of radiation hazard, risk communication, ethics of radiation protection, radioactive waste.*

Introduction

Since 2008, large-scale work has been carried out in Russia to eliminate the Soviet nuclear legacy within the framework of special federal target programs to ensure nuclear and radiation safety. At the same time, a new field of activity is being formed — the decommissioning of nuclear and radiation hazardous facilities. The final isolation of radioactive waste (RW) is carried out by the National Operator — FSUE “NO RAO”. Over the past 15 years, the first two stages of a near-surface disposal facility for radioactive waste of classes 3 and 4 have been put into operation in Novouralsk, Sverdlovsk Region.

Currently, similar facilities are under construction in the Tomsk (Seversk) and the Chelyabinsk (Ozersk) regions. In the Krasnoyarsk region (Zheleznogorsk), construction efforts have been underway since 2018 to build an underground research laboratory (URL) in the rock massif at the Yeniseiskiy site with a parallel study and clarification of

the characteristics of the selected subsoil area, potentially suitable for a deep geological repository (DGR) for RW of the 1st and 2nd classes. Final decision on the DGR construction is expected around 2035–2040 based on the URL research and safety assessments [1].

According to the law, public acceptance is seen as a must when it comes to the development of any RW disposal facilities (RWDF). This requires serious efforts by the National Operator, since RW disposal activities inevitably activities a priori cause a negative reaction from the public. The National Operator faced it at the preliminary stages of its activities in all candidate regions proposed for new RWDF construction. Most harsh public response was encountered in the Leningrad region with certain signs of politicization of this issue. Largely for this reason, RWDF construction in the Sosnovy Bor city was removed from the agenda. In four other regions,

NO RAO has managed to mitigate the negative public response, including the one in the Krasnoyarsk region.

There are several inveterate opponents of the DGR construction in the Krasnoyarsk region, who constantly waking up the public. However, they are supported neither by the population nor by local or federal authorities [2]. Thus, in 2015, public hearings held in Zheleznogorsk to discuss the siting and construction license application for the URL ended up with a positive statement supporting its construction with 254 votes in favor and 49 votes against the proposal [3]. The petition “We demand to ban the creation of a federal radioactive waste repository near Krasnoyarsk”, DGR development posted on the Internet in 2013, was signed by about 150 thousand people over ten years. For comparison, in 2019, the petition “Release killer whales and beluga whales from the Whale Prison in Srednyaya Bay” was signed by over 1.5 million Russians in a couple of months [4].

The current loyalty of local authorities and the population in general does not provide guarantees for the future. The final decision on DGR construction is going to be preceded by a public hearing focused on the DGR safety [1]. To overcome this milestone successfully, over the next 15-20 years the stakeholders should ensure that public support is maintained/increased at all levels, including the federal one.

NO RAO continues its efforts in this area mainly at the local (municipal and regional) level. Since 2017, NO RAO has been continuously communicating with the Public Chamber of the Zheleznogorsk city and the Public Council established under the Ministry of Ecology and Rational Natural Resource Management of the Krasnoyarsk region. In September 2023, a Memorandum was signed enshrining the participation of the Public Council members in sampling activities implemented to monitor the condition of liquid radioactive waste (LRW) storage facilities, preliminary examination of environmental reports issued by NO RAO to comply entirely with the requirements of the interested parties, etc. [5]. Technical tours have been arranged on a regular basis to familiarize the interested public and journalists with the construction activities implemented at the site.

Lessons learnt by other countries show that in addition to municipalities/regions opposing the idea of having a DGR “in their backyard” (NIMBY syndrome¹), the municipalities/regions crossed by

relevant transport routes or located in their vicinity can join the public discussion. Socio-political risks may arise at the national level as well. Along the DGR development, several generations will change, including the political ones. The final decision made by the Government may also be highly political in its essence [8]. The most notable cases in point are the Yucca Mountain project in the US and the Gorleben site in Germany closed permanently at the turn of the 2010s and in 2021 respectively, etc. [9], [10]. Therefore, long-running RW disposal projects are now judged successful only given sustainable public support provided both at the national and local levels throughout the entire implementation time [11]. So far there are only two successful cases in the global practice, namely, those of Finland and Sweden, whereas most of nuclear power countries are still striving to select suitable DGR sites [12].

At the national level, challenges associated with the public opinion can be addressed effectively only with a proper understanding of the a priori public attitude towards DGR safety. RW management issues have never been widely discussed in Russia with no systematic sociological studies implemented on this topic. All-Russian and regional opinion polls conducted by the ZIRCON research group commissioned by Rosatom did not address the problems of the backend and the perception of radiation danger. Longitudinal studies by the Public Opinion Foundation (FOM) in 2006–2012, devoted to the public perception of the consequences of the Chernobyl accident and attitudes towards nuclear power, in some way touched upon these topics [13], [14].

In 2023, the Nuclear Safety Institute (IBRAE) conducted an all-Russian online public opinion survey on the topic of DGR and radiation risk perception. The questionnaire was developed taking into account relevant questions from the past FOM studies and the 2008 Eurobarometer survey on the topic “Radioactive waste” [13]–[15] in order to use their findings as secondary data.

This paper evaluates the findings of the online survey comparing them with data from the previous studies. The identified public perception issues are discussed in the context of radiation risk communication along the long-term DGR safety assessment process.

Materials and methods

For the online survey 9 questions were prepared to test three hypotheses: (1) radiation risk perception governs negative attitude towards the construction of nuclear and radiation hazardous facilities near

¹ NIMBY (an acronym for Not In My Back Yard) is widely used in socio-political discourse often with a negative connotation; for this reason, it is judged as misleading by social psychologists [6], [7].

the residence area of the respondents, (2) the perceived DGR hazard level commensurate with the one of a nuclear power plant (NPP) and (3) public perception of the medical consequences associated with the Chernobyl accident did not changed over the past decade.

The online survey was held in mid-April 2023 based on the Yandex Vzglyad Internet service (hereinafter referred to as the online survey). The respondents were the users of the Yandex Advertising Network platforms (average daily audience of over 50–60 million people) aged 18 years and over living in Russia [16]. The sample size involved 1,000 people from 75 regions of Russia. Due to the *digital divide* and *self-selection*² effects [17], [18], the socio-demographic structure of the online survey respondents generally differed from the one of the Russian population: mostly men (56%) and residents of large cities (14% of the questionnaires were filled out by Muscovites). Almost half of the respondents (47%) accounted for those of prime working years (from 31 to 45 years), more than half (56%) of the respondents were university graduates. For this reason, it was not correct to compare the online survey findings directly with those of the all-Russian FOM survey. However, at a qualitative level such comparison is acceptable.

Findings

Online survey findings were grouped according to relevant topics in Tables 1–3.

Table 1. The breakdown of answers covering the NIMBY topic presented as a percentage of the total number of the respondents engaged in the survey

Question: If they decided to build /a multi-lane highway / waste incineration plant / nuclear power plant/ near your place of residence what would be your reaction – positive, negative or indifferent? (One answer)				
Facility	Definitely/ rather positive	Indifferent	Rather/ definitely negative	Not sure
Multi-lane highway	19.2	10.3	67.2	3.3
Waste incineration plant	6.4	3.0	89.1	1.5
Nuclear power plant	11.7	7.5	78.2	2.6

² Responses are provided by volunteers, i. e., members of the public having interest in the topic of the survey and a desire to participate – most active and curious Internet users.

Table 2. The breakdown of answers on the topic of radiation risks presented as a percentage of the total number of the respondents engaged in the survey

Question: Do you think that since the Chernobyl accident, the likelihood of a large-scale disaster at nuclear power plants has increased or decreased in our country? Or nothing has changed in this regard? (one answer)					
Has definitely increased	Has more likely increased	Nothing has changed	Has more likely decreased	Has definitely decreased	Not sure
5.1	10.1	22.2	33.7	20.3	8.6

Question: /In 1986 there was an accident at the Chernobyl nuclear power plant/in 2011 at the Fukushima nuclear power plant in Japan/In your opinion, how many people died from the radiation exposure caused by this accident? (One answer)		
Answer options	At the Chernobyl NPP	At the Fukushima NPP in Japan
1. No one	0.4	1.1
2. Very few	1.2	1.7
3. Tens	2.9	6.0
4. Hundred	8.5	14.2
5. Thousands	22.5	22.1
6. Tens of thousands	25.1	17.5
7. Hundreds of thousands	18.2	12.7
8. Over a million	9.3	7.4
9. Another answer	0.3	0.3
10. Not sure	11.6	16.9

Table 3. The breakdown of answers on the topic of DGR development presented as a percentage of the total number of the respondents engaged in the survey

Question: Compare the danger level inherent in a nuclear power plant and a deep geological repository (one answer)	
Nuclear power plant is more dangerous than a repository	14.0
Both facilities are approximately equally dangerous	42.7
A repository is more dangerous than a NPP	32.1
Both facilities are quite safe	3.8
Not sure	7.4

Question: If they decided to build a deep geological repository near your place of residence what would be your biggest concern? (One answer)	
Disturbance of the natural environment and temporary inconveniences inevitably caused in the vicinity of large construction sites	9.1
Possible accidents during the transportation of RW containers and their disposal	11.0
Possible radiation impact on the environment and health risks for the residents	65.1
Possible terrorist threats	3.8
Strong drop in real estate prices	4.6
Other answer	1.0
Not sure	5.4

Continuation of Table 3

Question: High-level waste in Russia is going to be disposed of in a rock massif by means of establishing a purpose designed structure at a depth of several hundreds of meters. This option is considered optimal by the international expert community. How much credence do you give to this expert opinion? (One answer)				
I have full confidence	I'm rather confident than not	I'm rather not confident, than confident	Not confident at all	Not sure
11.6	43.0	23.4	9.2	12.8

Discussion

Attitude towards the final RW disposal. Experts believe that the problem of long-lived high-level waste (HLW) can be preferably addressed by means of its disposal in deep geological formations. The online survey showed that the respondents were quite neutral about this: over half of them trust the expert opinion, but there are also quite a lot of people who disagree with this point of view - about a third of the respondents (Table 3). It should be noted that in 2008 the overbalance in the votes of Europeans, who tend to be generally more aware of the RW problem, was less considerable: 43% supported the idea of deep underground disposal with only 36% of the respondents who voted against [15].

When the RW disposal issue touches upon the respondents' immediate circle of interests, their attitude tends to be more negative. In the online survey, answering the question "If they decided to build a deep RW disposal facility near your place of residence, what would be your biggest concern?" most of the respondents (~65%) chose the option "radioactive environmental contamination and radiation health effects" (Table 2). Transport accidents and terrorist threats are also indirectly related to radiation hazard perception (radiation exposure/contamination due to an inadvertent or intentional accident), drop in the real estate prices reflects respondents' perceptions of other people's radiation risk perception. Purely non-radiation factors associated with large construction were ranked first by about 10% of the respondents. For comparison: the vast majority (~80%) of Europeans answering the same question in 2008 were attributing their concern specifically to the radiation factor [15]. Thus, in Russia, as in Europe, people do not wish to live in the vicinity of a repository mainly due to their perception of radiation hazards.

Radiation hazard perception. Comparing the hazard level of a disposal facility and a nuclear power plant, two-thirds of those responded to the online survey claimed that the disposal facility was as dangerous as a nuclear power plant, or more (Table 3).

New NPP construction is a typical NIMBY case: such initiatives in "non-nuclear" regions are met

with hostility by local communities all over the world. The vast majority (80%) of the online survey participants also had a negative attitude towards the idea of building a nuclear power plant near their place of residence. Comparable results were obtained by the FOM in 2006, 2011 and 2012 — the share of those opposing such projects was ranging from 70% to 80% of all the respondents [13].

For online survey respondents, the idea of a NPP construction near their place of residence turned out to be unacceptable to an approximately same extent as the construction of other large infrastructure facilities — a multi-lane highway and a waste incineration plant (Figure 1), although from a technical perspective the radiation risks associated with nuclear power plants are several orders of magnitude less than the toxic risks from a waste incineration plant³ or a multi-lane highway [19], [20]. All three facilities were perceived as a source of environmental pollution (radiation/chemical) and were associated with an unfair risk/benefit distribution, i. e., when risks are concentrated in one place whereas benefits accrue to the region or country as a whole.

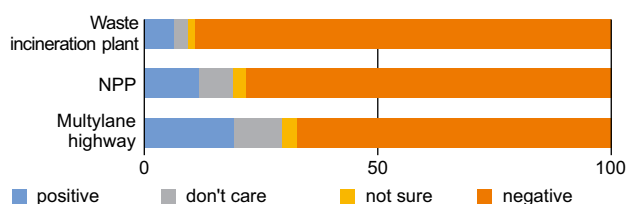


Figure 1. Breakdown of answers to the question: "If they decided to build / a multi-lane highway / waste incineration plant / nuclear power plant / near your place of residence, what would be your reaction - positive, negative or indifferent?", as a percentage of the total number of respondents, online-survey, 2023

It is known that radiation danger of an NPP in mass consciousness is perceived through the prism of Chernobyl, and this is clearly visible in the linguistic consciousness. According to the Russian language web dictionaries KARTASLOV.RU and SINONIM.ORG, the most common association with the word NPP is Chernobyl. Most Russians consider the radiation consequences of this accident as catastrophic. This was first clearly demonstrated through the findings of the all-Russian FOM 2012 survey: every fourth respondent was undecided in answering the question "How many people died due to the radiation effects of the Chernobyl accident?" The overwhelming majority (87%) of the rest of the respondents answered that thousands, tens of thousands or more people died [14]. Among

³ Incineration, not thermal waste processing.

those who took part in the online 2023 survey, the proportion of respondents who doubted their knowledge was half as much (12%); but even in this case, the predominant number (~80%) of those who did chose a certain answer claimed that thousands, tens of thousands or more people died from radiation (Table 2).

Respondents also claimed that the radiation consequences from the accident at the Japanese Fukushima Daiichi NPP could be judged as catastrophic. The overwhelming majority of “knowledgeable” survey participants believed in 2012 and believe now (2023) that Fukushima radiation claimed the lives of thousands, tens of thousands or more people [14].

Thus, over the past decade, public perceptions about the catastrophic nature of the Chernobyl and Fukushima accidents and their medical consequences, in particular, have not changed nor have changed people’s attitudes towards NPP construction in the vicinity of their households. This stability contrasts with a notable improvement in Russians’ attitudes towards nuclear power in general: according to the ZIRCON research group, the period from 2007 to 2022 saw a twofold increase in the proportion of respondents supporting its use [21]. Moreover, in recent years, Russians have become less afraid of accidents at nuclear power plants. According to the Levada Center, in 2006–2019, the share of respondents who considered it (quite/fairly) likely that a Chernobyl-type accident could recur in the near future dropped from 60% to 30% [22].

Growing support for nuclear power provided by the Government in the past 15 years have apparently contributed to some positive trends in this regard. As for the public perception of the Chernobyl consequences and radiation risks in general, multiyear efforts of the professional radiological community seeking to improve it were actually fruitless.

The judgment regarding the mass casualties caused by the Chernobyl radiation were wrapped in the 1990s, when this topic was highly politicized. In 2001–2005, an international consensus was reached regarding the limited nature of the medical consequences caused by the accident and the predominance of humanitarian problems over the medical ones. Over the next decade, concerned UN organizations had made systematic efforts to inform national governments, journalists and the world community about the expert consensus. Scientific reports, fact sheets were published, press conferences, international forums, workshops were held, an international information network on Chernobyl (ICRIN) was established, etc. [23], [24]. 30 years after the accident, the final brochure titled *Radiation: Effects and Sources* was released

to the public by the Secretariat of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) sponsored under the UN Environment Program. The brochure presents scientific evidence on the radiation consequences of the Chernobyl accident considering some general knowledge on radiation and its impact on humans and the environment [25].

Since the late 1990s, under the auspices of the Russian Ministry of Emergency Situations, several international projects have been run in Russia to inform various target audiences, including the liquidators and the residents of radiation-contaminated areas [26]. Every five years, national reports on the consequences of the accident and progress in the implementation of federal and Belarus-Russia union state programs were published and presented to federal media journalists [27]. By 2016, the decision was made to complete the federal Chernobyl program. Subsequently, systemic efforts seeking to raise public awareness in Russia have been discontinued.

As a result, the media field today involves almost an entire range of estimates on the number of deaths caused by the Chernobyl accident – from 28 to 600–900 thousand people [28]–[30]. Most often, Internet authors referring to “official” data (the 2005 International Chernobyl Forum, the UN, the Russian Academy of Sciences, the National Commission for Radiation Protection of the Population of Ukraine, etc.) report tens and hundreds of thousands of deaths. In some cases, quite considerable uncertainties are noted in the estimated medical consequences of the accident [30].

Reasons for the persistence of public perception of radiation danger. Persisting public perceptions regarding the catastrophic radiation consequences of the Chernobyl accident reflect the ambiguity and vagueness of scientific statements on the long-term effects of low-dose irradiation on the population: “...the long-term radiation exposure doses were relatively small, ... which is unlikely to lead to any considerable medical effects in the population” [25].

The inability of providing a clear answer to the question deemed as extremely important for society about the number of deaths/injuries resulting from the severe radiation accidents stems from a particular approach to radiation regulations adopted by the scientific community early in the nuclear era and which neither UNSCEAR nor ICRP intend to abandon. Thus, following the “duty of vigilance” in relation to man-made radiation, ICRP recommends that in dealing with radiation protection issues one should be wedded to the idea that any however small dose of radiation can cause harm to health.

Since seven decades of dedicated efforts have failed to prove or disprove the harm from low-dose radiation (< 100 mSv), UNSCEAR and ICRP remain committed to this approach, which has strong (though not unquestionable) ethical grounds [31]. The exaggerated public dread of radiation, regardless of its dose, seems being a side effect of this particular ethical position.

A broadening approach to public outreach. Recognizing the public demand for understandable and clear answers, UNSCEAR and ICRP believe that scientific knowledge should be as simple as possible, but not simpler [31]. However, the Chernobyl case demonstrated that within the framework of a purely scientific approach, they fail to communicate with society.

ICRP is currently broadening its approach to the public outreach. Already in the 2007 ICRP recommendations it was noted that "... scientific estimations and value judgements should be made clear whenever possible, so as to increase the transparency, and thus the understanding, of how decisions have been reached" [32, par. 27]. In 2018, in Publication 138 "Ethical Foundations of the System of Radiological Protection", the Commission stated that it was willing to discuss with all interested parties the "the inherent value judgements made in achieving the aim of the radiological protection system" and noted that "the traditional emphasis on the science of radiation by the Commission has been shown to be insufficient, and it is now acknowledged that human and ethical dimensions of exposure situations are also important, and sometimes decisive, in both the decision-making process and in communication, particularly when engaging with stakeholders" [31, par. 4].

It is clear that the dialogue with the public on the ethical aspects of radiation protection has nothing in common with the propaganda arguments expressed by some domestic specialists claiming that the decisions aiming to protect the public and the environment cannot be "immoral", or declaring the thesis of "radiation equivalence" as "the main ethical principle in nuclear power", etc. [33], [34]. The debate unfolds between those promoting utilitarian ethics, in which "the best action is the one bringing about the greatest happiness to the greatest number of people," and adherents of egalitarianism arguing that all people are equal and have the right to equal protection.

The range of ethical problems of radiation protection is quite extensive, many of them can be discussed in connection with the RW disposal issues [35]. For example, the ethical basis supporting the fundamental principle of activity justification is discussed in light of unfair risk-benefit

distribution; the precautionary principle is directly related to radiation risk and long-term DGR safety assessment.

The justification principle authorizes the utilitarian ethics: any additional radiation exposure should be always justified in terms of the benefit it brings. In other words, the collective benefit justifies additional individual exposure. Egalitarian theory states that exposing a group of people to greater risks without adequate compensation or without a strong moral reason is tantamount to discrimination [35]. The IAEA Safety Fundamentals and the Joint Convention for the Safety of Spent Nuclear Fuel Management and the Safety of Radioactive Waste Management openly endorse the egalitarian ethical standards of "equality of people over time" — future generations being treated on an equal basis with the current ones. Although, the principle of "spatial equality" is not enshrined in international regulations, many countries still adhere to it under their DGR development projects providing the host communities with various socio-economic benefits, including considerable financial compensation. The case in point are Finland and Sweden that achieved the greatest progress in the DGR development, as well as some other countries with less apparent progress achieved in this area (Canada, UK, etc.).

The precautionary principle requires active efforts to prevent harm to the environment and human health, which should be undertaken even in case of scientifically unproven concerns about the harmful consequences of a proposed activity. These concerns are taken into account in the radiation risk assessments and applied, in particular, to demonstrate the long-term RW disposal safety.

Public debates of 2008–2015 held in Finland and Sweden, that have successfully completed the main DGR licensing stages, have basically revealed three groups of ethical issues: (1) fairness of risk/benefit distribution; (2) procedural objectivity: transparency, stakeholders engagement in the decision-making process, sufficiency of available knowledge for the final decision, trust to regulators, scientists, operating company, responsibility of RW generators for waste disposal; (3) fairness between different generations, liability to future generations, the ability to adjust the implemented decisions in the future [36].

ICRP's Publication 138 provides opportunities for the radiation protection expert community to engage on meaningful discussions of this kind. Moreover, a clearer picture of the ethical basis standing behind the fundamental protection principles seeps away the illusory contradictions in the system of standards regulating the radiation risks that tend to confuse the public.

Conclusion

In our country there not yet conditions not only for public, but also for expert discussions on the ethical aspects of radiation protection and deep RW disposal. Anti-nuclear proponents raise these issues from time to time with only few Russian experts being concerned with this issue [35]. Recent discussions on the so-called principle of “radiation equivalence” have been focused on the inconsistency of relevant scientific evidence and does not touch upon any ethical aspects [36]–[38].

Given the current setup, to provide sustainable long-term public support for the National Operator and its activities, including those implemented in the Krasnoyarsk region, socio-humanitarian experts should be engaged yet today, namely those having hand in the theories and methods from various fields of knowledge (communication, social sciences, ethics of technology and etc.), to develop the two-way risk communication models both at the local and national levels, including expert and public discussions of ethical aspects associated with radiation protection and RW disposal.

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