

Public's perception regarding the major impacts of radioactive nuclear waste. A research study in Romania.

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Abstract. *Like all other human activities, nuclear activities inherently produce waste. Even if the amount of radioactive nuclear waste is small compared with every other waste generated by human, this is a real danger and may produce devastating effects. Radioactive nuclear waste requires a safe management, a very good classification and limitation of releasing of radioactive effluents into the environment. The anticipated big impacts that any nuclear activity releases involve the environmental impacts, human health and safety. Public's perception represents a big challenge mainly when people are asked about harmful activities or technologies, such as radioactive nuclear waste. The aim of this study is to find out the public's perception of the impacts of radioactive nuclear waste. The main research instrument for this analysis is based on questionnaire. This research represents a new approach for the study of people's perception of radioactive nuclear waste in Romania. Public's perception is one of the key factors with influence on the development of nuclear waste technologies. The perception is crucial and may mean more than reality. The impact of radioactive nuclear waste seen through public perception shows the degree of development of storage conditions, both in the short and long term. The study revealed that the public perception regarding radioactive nuclear waste is divided in two major concerns: the potential impacts on the environment and people's health.*

Keywords: radioactive nuclear waste, radioactive nuclear waste deposit, environmental impact, health impact, safety impact.

Introduction

Starting with human evolution the energy consumption became more and more important reaching today to be a real energy addiction. Tacking in care the fact that people feel more comfortable with the conventional energy generated by fossil fuel or coal, we have to lift the head and take the attitude considering the environmental issues as carbon dioxide emissions, climate change, global warming or exhaustion of natural resources (Xueliang Yuan et al., 2015). If we do not forgotten the problems regarding the incapacity to generate constant energy it will be a good idea to think more in searching for other ways of generating energy.

Nuclear energy is one of the most rewarding source of electricity (OECD.NEA, 2012). The factors that can influence the degree of innovation of a nuclear facility are: safety, security, health and environmental protection, social acceptance and economic issues.

Nuclear energy represents a sustainable factor for economic evolution and improvement of people prosperity. Nuclear energy provides access to clean, reliable and affordable energy without having a negative impact on climate change. This kind of energy represents a significant part of the world's energy mix and its use is expected to grow in the coming decades. The nuclear energy sector is in a continuous development, focusing on the efficiency and support of new nuclear programs, catalyzing innovation and building objectives in planning, analyzing and managing information and knowledge. Research in the

field pursues innovation in the nuclear fuel cycle, from uranium mining to the management of spent fuel and radioactive nuclear waste.

Considering the nuclear power plants as energy supplier, north America, south America, Africa, Asia, East Europe and Russia had, in 2016, a greater capacity to generate energy than the capacity average of the 2011-2015 years. The single one who doesn't have higher generation was west and central Europe (WNA, 2016). In case of Romania the total nuclear electricity production is around 17,09% in 2016 (IAEA.PRIS, 2017, December).

Nuclear energy industry was developed as a potential source of energy cheaper than its rivals. This aspect is accompanied by the fact that nuclear fuel costs are less than the fossil fuels costs, with approximatively 10% (CNE CANDU, 2015). The production of electric energy by the nuclear power plants is a nonaggressive technology without effects on the environment during it's operation. Nuclear energy helps also to reduce the harmful emissions (Xueliang Yuan et al., 2015). In the next 20 years the energy request will increase with approximatively 30%. In the global energy mix the nuclear energy weight will increase with almost 10%. The region with the highest increase of nuclear fuel demand is China followed by India and Japan. In the end of the rankings is European Union. While some want to quit the nuclear power, others keep the nuclear option or follow one. The total life of a nuclear power plant is between 40 and 60 years, but with this uncertain future a refurbishment of the outdated plants is preferably (IEA, 2015).

Public's perception regarding the disposal of radioactive nuclear waste

Public's perception is included through the biggest challenges mainly when people are asked about harmful activities or technologies. Public's perception is shaded by various factors, as media, newspaper, lack of knowledge or just by circumstances.

In case of radioactive nuclear waste, the risk is defined as "dread risk", something terrible, awful with great apprehension of fearful (Slovic, 1987). Apart from direct harm of radioactive nuclear waste, some other impacts include indirect costs for which responsible are the government or industry companies. Indirect impacts include also death, injuries or materials damages.

The public's acceptance is directly proportional to risk associated. Acceptance and opposition of a nuclear waste repository are often in the top of the studies because of the potential impacts. The public accept very hard a nuclear industry considering the benefits quite small comparing with the risks which are almost unacceptable. Public's perception based on unknown of real risk of radioactive nuclear waste leads to irrational fear. The danger is evaluated through the information received by media and not by the experts. The public cannot be educated in line with the industry scientists because the lack of interest and big blind trust in fake publicity (Cohen, 1983).

Informing the public is very hard when they show big opposition to nuclear technologies (Slovic, 1987).

Other characterises, as age, sex, education or socioeconomically aspects, influence the public perception.

Regarding the benefits or compensations offered, people tend to accept or not a nuclear waste repository according to their perception of risk. When they see a high risk in nuclear waste technologies they totally refuse any compensation.

Environmental impacts of radioactive nuclear waste

Nuclear energy has a positive impact on the environment because it does not generate carbon emissions.

This type of energy is recognized by all competent international authorities as being a technology with no emissions. Also it plays an important role in reducing greenhouse gas emissions in this field and also as low carbon source is the second one after hydro energy (OECD. NEA, 2012). Nuclear energy can easily participate at the global energy mix with some particular aspects depending on certain economic or political conditions of every country.

The potentially major impacts of nuclear radioactive waste are above environment, human health and safety, all of them because of its radioactive behaviour.

In case of environment some people's concerns are manifested on the following issues: soil, air and water, natural resources, vegetation, animals, marine life, biodiversity, climate change.

Most of the nuclear diseases are inevitable and have two sources for generation: nature and human. Beside the goods of the nuclear energy as clean, productive and less expensive source of energy, the concern about the safety is an important topic when it comes about nuclear energy.

Producing energy throughout nuclear facility, undersigned waste is also produced. All this waste is radioactive for million years. When we think about the waste we know that any man-made activity leaves behind some products that can no longer be used as such. Starting with the invention of X-ray tube and discovery of natural radioactivity, humanity used both of them for different activities in medicine, research, industry or agriculture.

The problems related to nuclear power with considerable impacts over the environment, health and safety appear because of its radioactive nature considering some accidents which can occur. Radioactivity represents a natural phenomenon as many others. In the environment can be found many natural radiation sources. Simultaneously with power production there are other applications of radiation or radioactive material as: medicine such diagnostic radiology, nuclear medicine and radiotherapy, industry, agriculture, research and academic work, security and protection systems (Ojovan and Lee, 2014). All of these activities generate waste, but not all of them are the same. The waste is classified from exempted waste to high activity waste, depending on the life of the radionuclides. Another aspect which separates the low activity waste from the high activity waste is the thermal power (CNCAN, 2005). Considering high activity waste the most important point to be reached is safety.

The radioactivity creates some disadvantages of this facility. The biggest one consists of the appearance of an accident at the power plant and the second one is related to storage of nuclear waste. Other concerns consider all stages of the fuel cycle like: mining, fuel processing, electricity generation, reprocessing or storage with a dependence of the plant type (SDC, 2006). The risk arising from the exposure to radiation is higher for the communities situated in the surroundings of the plant but is not limited to that because can be affected all the host country and other neighboring countries.

Ionizing radiation represents a risk associated with exploitation of a nuclear power plant. The harmful effects of ionizing radiation coerce the people from around the world to protect the population and the environment. The recognized scientific authority in radioprotection is International Commission on Radiological Protection (ICRP) which issues recommendations to be used in international and national regulations in this field. The

recommendations of this Commission involve also the radiological protection of the environment and for people (OECD.NEA and ICRP, 2003).

The amount of radioactive waste is considerable and will increase in the future because the best technology and easy acceptable emplacement have not been found yet. One option is to minimize the waste through a process which aims to reduce the waste and also the activity of them. This waste minimization means to reduce the generation of waste and other processes related with them. This program was implemented and radioactive waste decreased more than waste generates by the fossil fuel considering the same amount of energy generated. Other steps for preventing the accidentally irradiation is to submit the waste to some processes designed to facilitate the transportation, handling and storage. Those processes have the aim to eliminate the contamination risk (Ojovan and Lee, 2014).

Considering this, storage of the nuclear waste must not be in contact with environment components, as: soil, water, air and human. In case of people, it's very hard to find an area to put the nuclear waste repository and the citizens accepting this (Foss, 2011). Storage of nuclear waste is a big concern for current generation with possible reflections on future generations. When an area is the host of nuclear technology, all people and surroundings are exposed to an unhappy event.

Stakeholder importance in nuclear industry issues and public involvement

In a respected and successful frame, the nuclear facility must include the population with all the sides. The regulatory authorities must be independent and capable to assist and support the nuclear power plant operators in their way to performance and safety operation. Public involvement in the decisions and clearness of the information regarding nuclear program will facilitate the acceptance (OECD.NEA, 2012). Environmental monitoring programs are important and aim to control the emissions and verify the limits and conditions imposed by the regulators both radiologically and conventionally.

In the world there is no other industry subject to regulations more than nuclear energy (Ojovan and Lee, 2014). Some international organizations were created along the time to protect the environment from the negative effects of radiation. Those organizations work together with the regulators and scientists. Protection aspects are split into two big missions: firstly to protect the population and other inhabitants from all species and the second one to protect the ecosystem (Andersson et al., 2009).

Recommendations emitted by international organizations can in some cases become legal standards for which the government is responsible.

In the last decades, beside other industries, nuclear energy started to be politicized. Political domination in this field creates a very competitive atmosphere between states.

Even through every single human in this world has its own opinion regarding nuclear energy we all are subjected at the same markets and governments (Carl and Fedor, 2017). Nuclear power plants represent all over the world a tool for political power and helps every state being independent.

This field cannot make progress if not all the stakeholders are involved. Government has the decision and represents the key part of this process by establishing and introducing the facility into the national energy plan. Other major stakeholders are represented by: regulatory body, researchers, mass-media and last but not least the public. Such a plan should take into account all the stages, as construction, operation and decommissioning

which represent for every state a long term engagement. If all the stages are outlined with involvement of all the stakeholders can be a success of this facility (IAEA, 2006).

Involving the public from the beginning makes acceptance easier, so transparency and good communication are an important factor for the development. Even if it's about a new nuclear power plant, a system for fuel cycle or a nuclear waste repository the population takes a crucial decision.

Public understanding not only makes easier the implementation of a nuclear power program but ensure also safety and security. In case of emergency is essential to have a plan. An emergency plan is absolutely to exist, and more than this it is very important to be developed together with the citizens (IAEA, 2006). If people individually or more people who represent an organization want to expose their comments the authorities must have in consideration their opinion.

Nuclear world need resources from all the stakeholders during its life cycle. Involvement of parts is essential for a responsible, safety and peacefully facility. Apart from those who are involved and responsible from every country, it's necessary to accept and to comply with the international legal instruments, internationally nuclear safety standards, and nuclear security guidelines and safeguards requirements. A good infrastructure is decisive whether even when it comes to producing energy, storing spent nuclear fuel or other related technologies (IAEA, 2006).

Research methodology

The research purpose was to investigate the public's perception in terms of radioactive nuclear waste. As research instrument, we used a direct questionnaire to evaluate the major impacts of the radioactive nuclear waste. *The questionnaire consisted of 18 questions and was divided into two sections. In the first one, have been identified information regarding participants and their specific aspects of employment. After that, the respondents were set to choose the right choice for their feelings having a set of different variants of response.*

This study was conducted through valuation method to determinate the major impacts of the radioactive nuclear waste. The valuation method is a complex process because there are no prices available for the radioactive nuclear waste. In a market without prices, the valuation method was used to determine the environmental goods and services by tracking the behavior of the population. In this landscape can be accessed two types of methods for economic value of environment and those are *revealed preference* and *stated preference methods*. Through revealed preference methods the consumers' behavioral is on the light to estimate the environmental goods. Using stated preference method the consumers' attitude is observed by surveys designed to reveal the importance of environmental goods and services for each individual. This method represents a proper way because outlined goods can be evaluated.

This research is based on a pilot study. The respondent's insights were compared considering their ages, gender, field of work, position and the classification of economic entities in which the participants are active. The questionnaire was transmitted via internet to a number of almost three hundred persons. At this questionnaire answered a total of 35 persons with different ages and backgrounds. The responses were collected in January, 2018.

Results and discussions

Considering the responses received through this study from Romanian citizens were established some of the major concerns in terms of nuclear waste repository. Almost 63% of survey respondents are more than 30 years and 37% of participants have less than 30 years.

The results showed which is the public perception when they face with the situation of high level radioactive waste generated by electricity production.

A percent of 80% from respondents think that nuclear radioactive waste requires a long term interest and not represent just a priority for the moment. If we take into consideration the actual generations the most important aspects is to care about the environment without affecting the natural resources or other inhabitants. A percentage of 74.3% of respondents sustain this and the rest of 25.7% is occupied by citizen's health. No one consider that monetary value is an important factor when we talk about the nuclear waste and their administration.

Participant's behavior towards radioactive nuclear waste major impacts

Public's perception was examined in order to discern the most important impacts of the radioactive nuclear waste.

As shown in Figure 1., 68.6% of respondents firmly agree that radioactive nuclear waste has a major impact on the environment, 25.7% think that citizens health is the most impacted issue, without caring about modern storage techniques and just 5.7% say that radioactive nuclear waste has an important impact on social life.

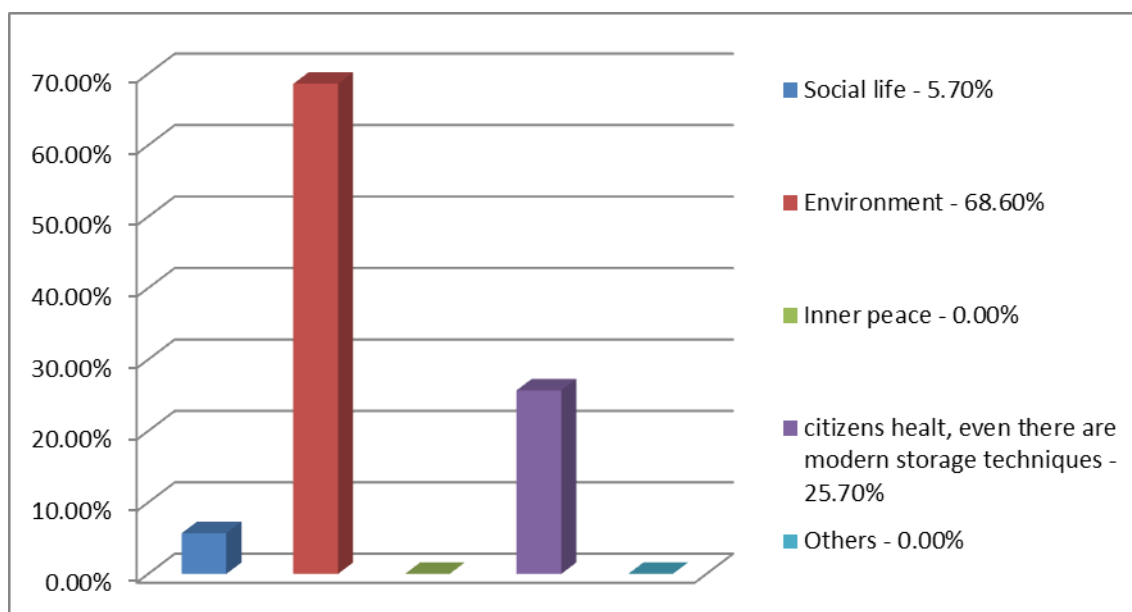


Figure 1. Respondent's answers regarding issues over which radioactive waste has significant impact

Source: Authors' own research.

Figure 2. comprise the responses regarding to accidents which can occur in transportation process from the reactor site to the repository. The majority answered that in case of an accident the biggest impact will be on the health of nearby people, summing 62.9%. A

percent of 22.9% think that some events like transport accidents creates troubles on vegetation and animals.

In case of a major catastrophe, as natural phenomenon, earthquakes, volcanic activity or tide the respondents are divided as follow: the most part of them, almost 50%, think that those kind of disasters creates problems for citizens life, followed by the environments impacts as flora and fauna in the surrounding, as can be seen in Figure 2. From the questions related to the major impacts of the nuclear waste and their storage resulted that in same proportion people think the environment and people's life are the most important aspects. The consequences of those waste affect public acceptance and without a good partnership between the state parts and population there will be no progress

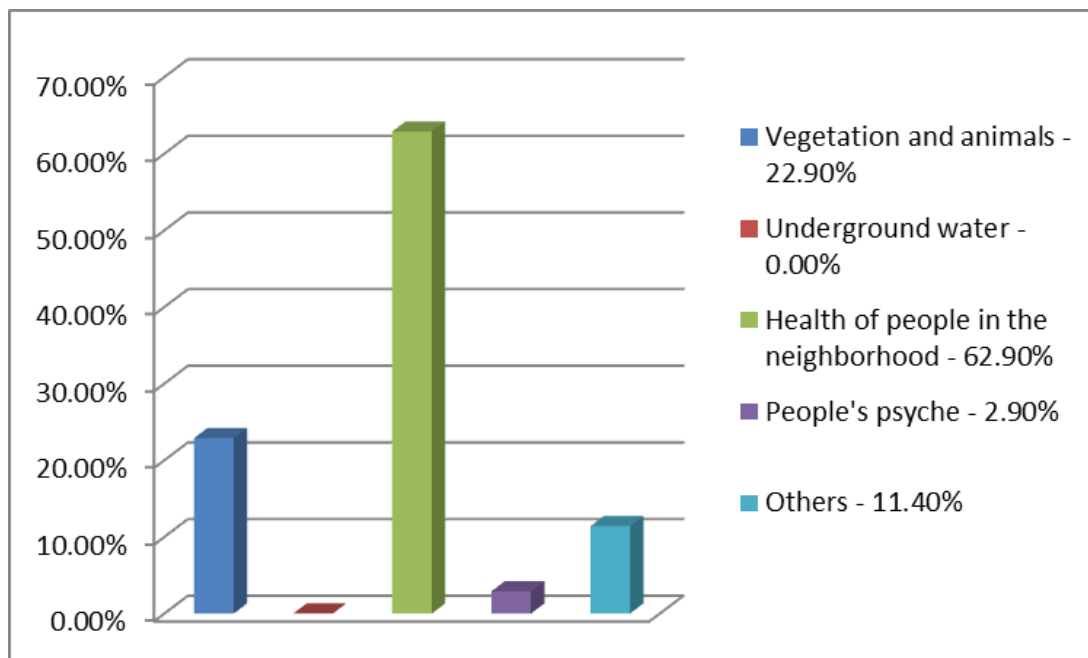


Figure 2. The most impacted issues when we talk about unforeseeable and dangerous events which can occur in transportation process of the nuclear waste

Source: Author's own research.

Participant's behavior considering stakeholders implication on the nuclear waste management

Main respondents think that state institutions are responsible to support the execution of a nuclear waste deposit. The percent of 57.1% is followed by the 34.3% percent which means that on the second place in the responses top is occupied by nuclear power plants committee. So, regarding participants the state institutions and nuclear power plants committee are the most capable to support the implementation of a repository and just a small amount of people think that local authorities or local authorities with other partners need to be involved in bearing the costs. In a similar proportion the responsibilities for finding solutions lies with state institutions or companied in the field and nuclear power plant personnel.

It was remarked that 88,6% of respondents strongly agree the idea that politicians, scientists and technologists need to provide more information about radioactive nuclear waste. This show to us that population wants to be informed and maybe this represent an important aspect related to public acceptance of this facility. Government authorities should implement the communication aspect between them and exposed population at every single stage of nuclear sector development. Fear, insecurity and distrust will disappear following this path not totally but in some extent. In the same way go also the responses when the individuals were asked about the acceptance degree of a nuclear waste repository in the area of the localities. A total percentage of 42.9% expressed that involving citizens in the project followed by the same percentage in case of offering shares to citizens in the companies involved in the project, offering attractive jobs for the locals or through financial compensations. Some of the respondents, in a small amount do not agree with construction of a nuclear waste repository in the area they live as shown in the Figure 3.

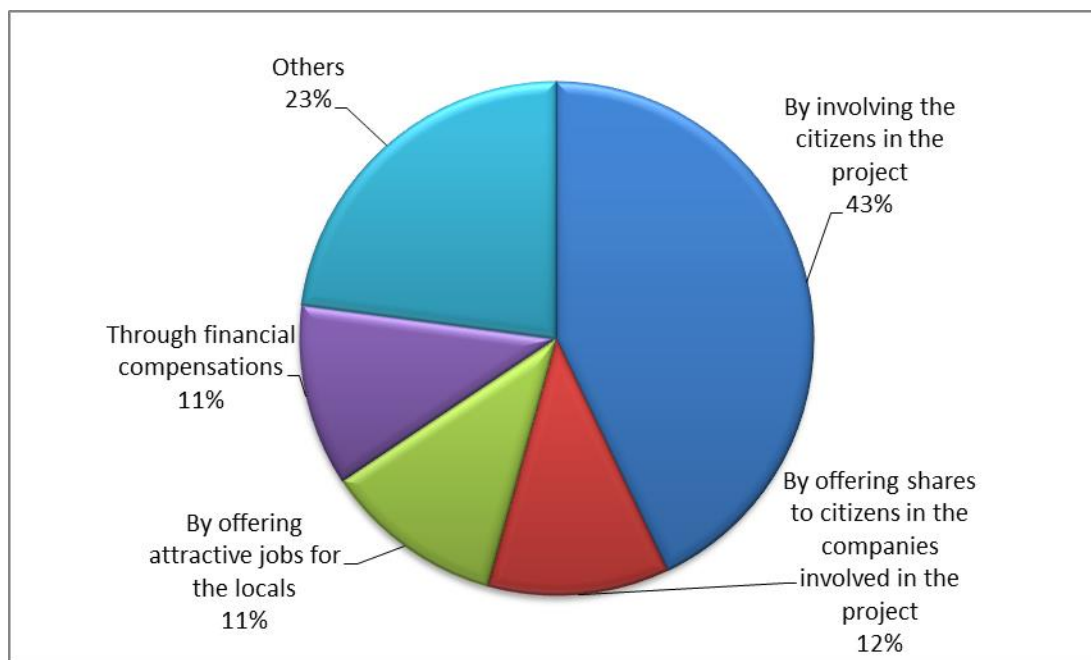


Figure 3. Respondent's opinion regarding the best ways to improve the degree of acceptance of a deposit in the immediate vicinity of the localities

Source: Author's own research.

When we put the respondents in the situation of living in an area near a nuclear waste repository they confirmed that will feel more comfortable if the existence of a technology for preventing the disasters will be possible. But not so far from here with around 23%, the respondents think that the calmness will come if the radiation level in the area is monitored daily and around 26% from the locals agree with getting daily reports about the quality of water, soil and air in the area. In the end of the ranking place the

response under which the convenience will appear if the city is always powered with organic food and filtered water.

As a note, the locals accept in some ways a repository close to their houses. They are open for implication in the project and the possibility of being always up to date facilitates acceptance. Figure 4. summarize all these aspects.

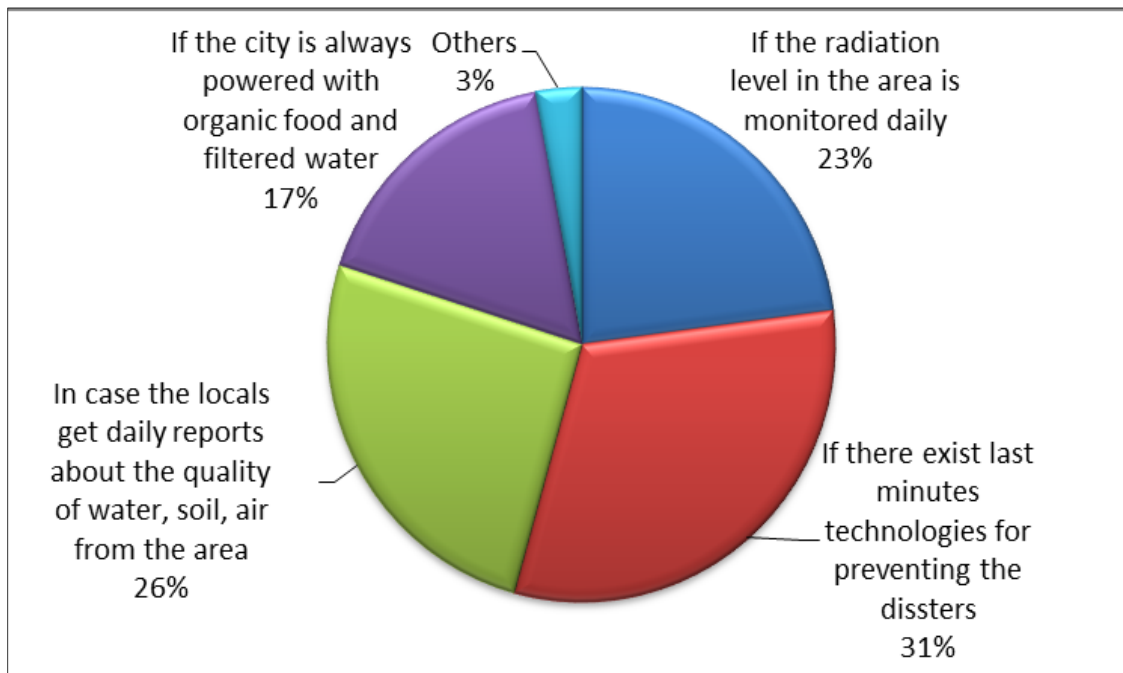


Figure 4. Most significant cases of living in a nuclear waste deposit adjacent area regarding respondent's feelings

Source: Author's own research.

Participant's behavior considering emplacement of radioactive nuclear waste deposit

When the participants on this survey were asked about the nuclear waste location, construction and radioprotection of the repository they showed concern and fear.

Location of a high level radioactive waste repository is a global issue and many countries which benefit from electricity generated by nuclear power plants face it. Our survey respondents are aware and think that the best way for nuclear waste storage is in a deep geological deposit taking into account the presence of natural resources. Those, which agree represent more than a half, almost 60%. Other opinions are divided and express that other great ideas for nuclear spent fuel emplacement are in the vicinity of the nuclear power plant, any area far from urban agglomerations or in arid areas without natural resources. All those results can be seen in Figure 5.

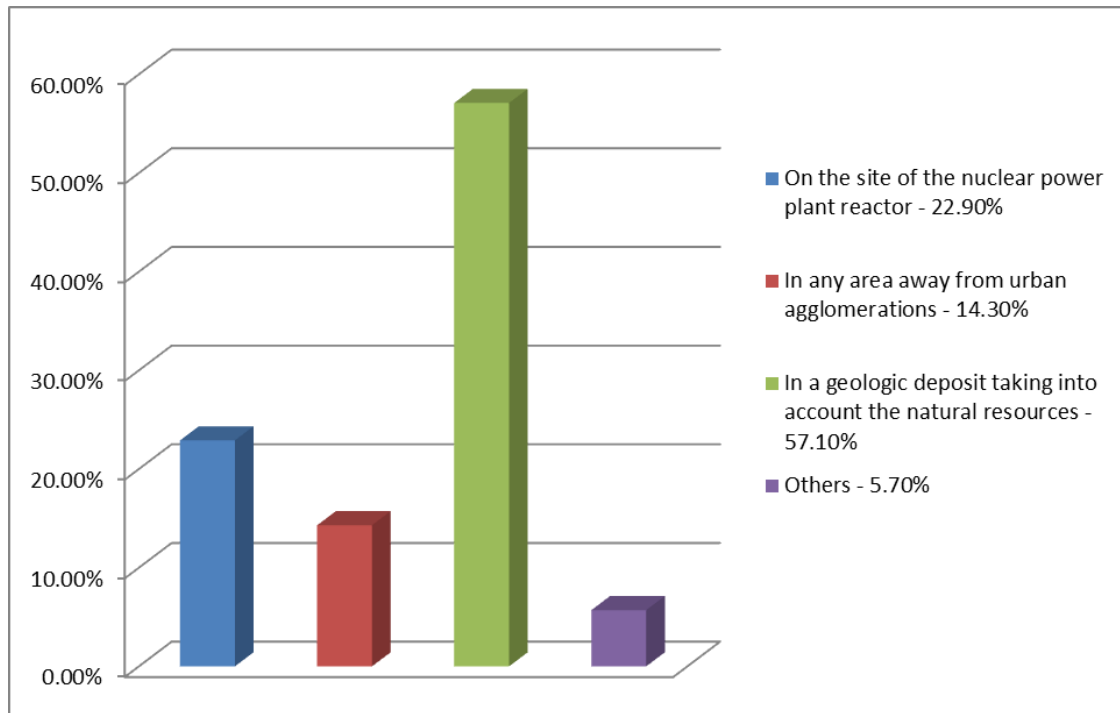


Figure 5. Respondent's opinion considering the most suitable area for the location of the radioactive nuclear waste repository

Source: Authors' own research.

At the same time, 43% of people consider that a nuclear spent fuel repository generates birth decrease when this is located close to the populated areas. Other disadvantage is that the investors can be stopped to open companies or factors in the area because of the ionizing radiation exposure of the personnel or goods. Almost 30% agree with this and other 20% of respondents believe that decreasing the number of the tourists in the region or even in the country will represent a factor for destruction of the economy as can be seen in the Figure 6.

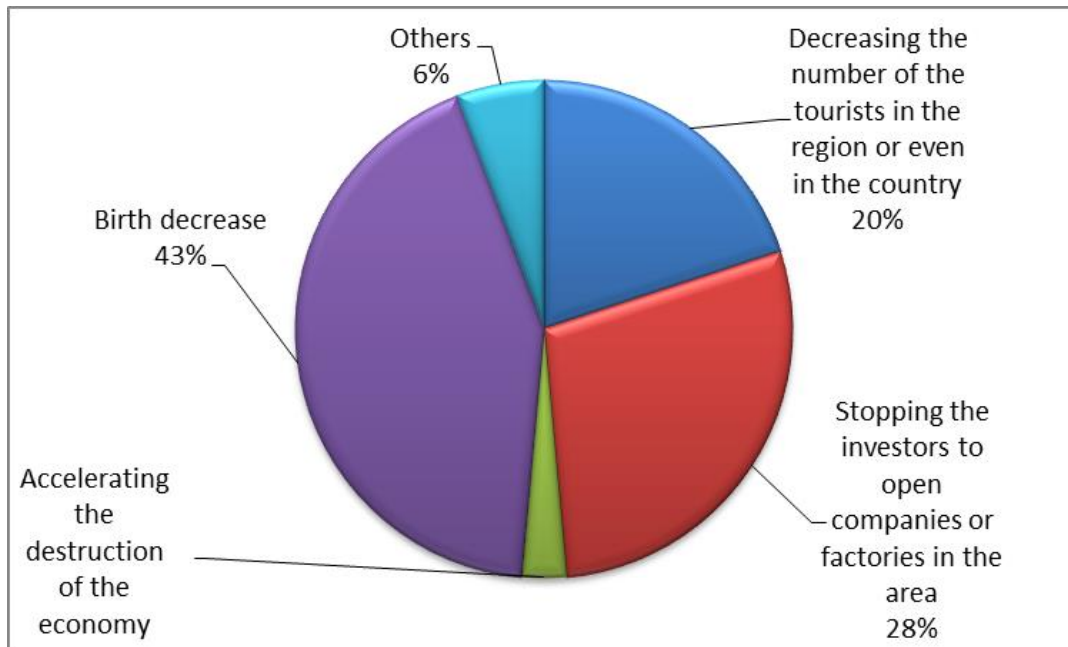


Figure 6. Disadvantages of locating the nuclear waste repository in populated areas

Source: Authors' own research.

Figure 7. indicates that people don't feel comfortable in case their homes are located near a nuclear waste repository. In this situation they want to exist always studies on radioactivity in the surrounding area. 42% of questionnaire participants agree with this. The fewest answers consisted in the fact that others would feel better if the deposit is located 10 km away. 22 % of respondents want to be well informed of new developments in technology regarding storage method, while some of them totally disagree with the idea of living near a nuclear waste repository and that they would never accept the placement of a deposit near the area inhabited by them.

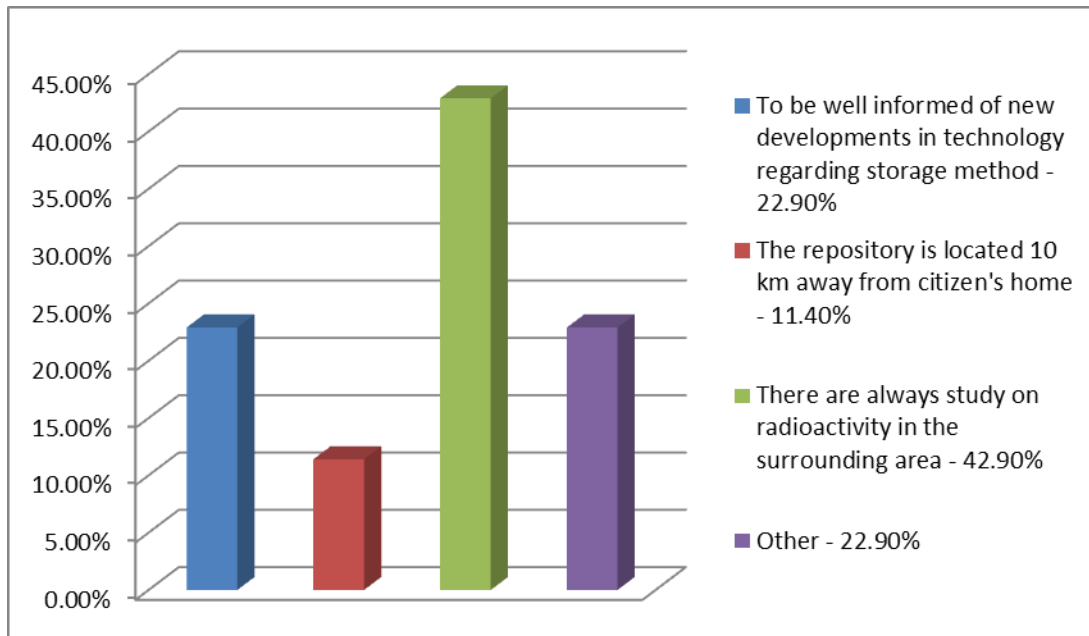


Figure 7. Respondent's acceptance of locating the nuclear waste repository near the people's houses.

Source: Authors' own research.

The most of those interviewed show awareness about nuclear waste and they think that the best place for a construction in this case is somewhere deep in a wild area with almost 36% of followers. The second option was near the nuclear power plant. But, as the terrorist attacks increased in the last years our respondents, 73% of them, agree with the fact that a nuclear waste repository must be additional guarded in order to not be in the face of a terrorist attack. Also, there is the possibility to not be necessary additional guarded depending of the location of this repository.

Conclusion

Following this study it has resulted that respondents express a slightly aggressive behavior when dealing with nuclear activities and radioactive nuclear waste in particular. Along the questionnaire could be observed how respondent's behavior alternate either in favor of environment issues or in favor of issues related to human health.

When it comes about different adverse events which can happen and which can have as main subject the radioactive nuclear waste, respondents consider that the possible effects may have a major impact on human health. From the questions related to stakeholders it turned out that all stakeholders have a certain importance in this domain and that there can be no independent involvement.

The emplacement methods and location of the radioactive nuclear waste repository creates concern among respondents. The majority sustained that emplacement should be made deep geologically without harm over the natural resources. Therewith those areas should be very far from urban agglomerations because their location near the localities can conduct to declining birth rates and destroying the economy for that area.

During this study the respondent's worrying was sustained showing a fear both for current generations as well as for next generations, although in a knowledgeable way they can show an opening to this uncertain industry.

Also it has been noted that there exist a difference between genders. Women are more aware about the people's health than men with a difference of 28.7 %. Through the study it was seen that men feel a bit more relaxed when they face with radioactive nuclear waste.

At the same time, the results of the study shows that safety plays a decisive role and has a big importance in terms of people acceptance.

In conclusion, could be observed that public's perception of the radioactive nuclear waste is divided in two major concerns, namely the potential effects on the environment and the people's health.

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