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Evacuation in the event of a nuclear disaster: Planned activity or improvisation?

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ABSTRACT

Previous research study into evacuation in the case of a nuclear disaster suggests that there is both a high degree of uncertainty about the actual implementation of plans as well as a need for the continuous study of the human aspects of nuclear emergency preparedness. Drawing on the results of a textual analysis of the Regional Plan, a survey of the inhabitants and interviews with representatives of the institutions located within the area of greatest potential threat, our paper seeks to establish the extent to which the population and institutions are prepared for an evacuation in the event of a disaster at Krško Nuclear Power Plant, in Slovenia. Our analysis reveals that, despite planning, communicating and training, almost three quarters of the population living within a three-kilometer radius remain unfamiliar with the locations of the reception centers; and two thirds of them are unfamiliar with the evacuation routes. As far as the institutions are concerned, the level of preparedness is also low due to a fatalistic attitude ('if the disaster occurs there will be no time to evacuate'), poor nuclear disaster planning, the low attendance of personnel at training sessions, poor coordination, and scarce attention and resources devoted to the management of a possible disaster.

Q3 Q4

1. Introduction

The Fukushima nuclear disaster in March 2011, caused by a tsunami, proves that accidents can happen even in the most developed countries in the world. As a result of this disaster, at least 210,000 people living within a ten-kilometer radius of the reactor and some 180,000 people within a 20-kilometre radius had to Q5 evacuate their homes [47].[1] The Fukushima experience has led to calls for all future nuclear power plants to be constructed in such a way that they have a near zero impact outside the plant boundary in the case of a malfunction or disaster [62]. However, despite the fact that there is no reason to assume that a similar nuclear disaster could not occur elsewhere, the current practice remains unchanged. For this reason, we should regularly assess the preparedness of our societies. We would expect that the evacuation lessons of Fukushima would clearly affect the level of evacuation preparedness in all developed countries.

The Krško Nuclear Power Plant (NPP) was built in the early eighties in the former Yugoslavia, and remains jointly owned by Slovenia and Croatia. It is the only nuclear power plant in Slovenia. So far, Krško NPP has met all safety and operational stability standards. Stress tests conducted by the European Union (EU) in the summer of 2011, as part of an assessment of 132 nuclear power plants in 14 EU member states, proved that Krško NPP was a safe installation [50]. The tests encompassed the safety of nuclear power plants in the case of floods, earthquakes, extreme weather conditions, plane crashes, and fires or explosions in the vicinity of the installations.[2]

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[1] The lessons of Fukushima confirm what has long been known: that, as a solution to a nuclear problem, evacuation can also create additional risks for the population and the community [34,6].

[2] It is however necessary to note that Greenpeace and other NGOs were critical of the tests and posed the following questions: why were evacuation plans for villages and cities overlooked? Why were the ages of the reactors not taken into account? Why did authorities not analyze the possibility of malfunctions in more reactors at the same time? And why were plane crashes not taken into account despite the plan that they would be? [18]. However, in the case of the Krško NPP, the potential for a plane crash *was* taken into account.

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If a major nuclear disaster were to occur at the Krško NPP, the threat to life would extend beyond the lives of the Krško NPP employees and the population in the vicinity of the power plant. The entire country of Slovenia and much of Central and South-Eastern Europe could be threatened. Therefore the preparedness of the population for evacuation is one of the crucial preventive and protective measures in the event of a nuclear disaster.[3] IAEA safety standards require that states and other relevant actors maintain an adequate level of preparedness (including planning and preparation) for a nuclear and radiological emergency [22]. However, the lessons of similar evacuation incidents suggests that this is not an easy task [23], and that local and national plans and supporting procedures need further improvement [24].

For this reason, it is vital to explore the various evacuation possibilities and their related feasibility. Girod [16] has emphasized that there have been many events in which people were not evacuated either timely or effectively, in spite of the existence of evacuation plans and even evacuation models. The problem lies partially with the fact that the plans and models have lacked a sufficient theoretical basis. The design and modeling of an evacuation should be based on sound socio-psychological theories and empirical findings concerning mass behavior in such instances [16]. To develop working evacuation policies, it is important to understand how people respond to evacuation alerts, including their choices of when to leave and which routes to take [58]. An individual's decision to evacuate is influenced by several factors which have to be taken into account when planning for an evacuation [7].

The research problem of the article is the evacuation preparedness of population and institutions/companies living and situated, respectively in the close vicinity of Krško NPP. Our main objective is to establish the level of evacuation preparedness and to warn about potential insufficiencies. We also want to offer a few recommendations based upon our research findings.

Notorious cases of nuclear disasters (Three Mile Island, Chernobyl and Fukushima) revealed several insufficiencies in the evacuation process. Concurrently, several empirical studies confirmed that we need to be cautious about the efficiency of evacuation in the event of a nuclear incident. Zeigler and Johnson [66] concluded people have their own ideas about how to behave during a nuclear accident and cannot be counted on to adhere to the advice on protective action issued by public officials. Research by Blando et al. [2] into the emergency preparedness of the general public located around New Jersey's nuclear power plants showed that knowledge of evacuation routes and some aspects of potassium iodide usage was incomplete among the general public. Japanese studies also confirmed the difficulties of implementing a cooperative evacuation plan due to the insufficient familiarity of residents with the plan prior to the disaster [61]. Some debates suggested that, contrary to popular opinion, the major challenge might not be evacuating hundreds of thousands of residents, but rather convincing them to stay put [55].

Despite those facts we formed a hypothesis that inhabitants and institutions/companies living and functioning within a three-kilometer radius around Krško NPP are prepared to adequately respond to the declaration of evacuation as planned by the authorities.

In order to confirm the hypothesis we first define an evacuation and its various forms and describe what we mean by evacuation preparedness. We also briefly explore evacuation planning. Following a theoretical review, we introduce our method and research instruments. We present the key features of the 'Regional Rescue and Protection Plan in the Case of a Nuclear or Radiological Disaster in Posavje' (henceforth: the Regional Plan) in order to identify the official expectations of how people and institutions ought to behave in the event of an evacuation. We then present the results of our survey and interviews. In the discussion, we attempt to determine whether the results of our analysis of the Regional Plan correspond with inhabitants' knowledge and behavior as recorded in the survey and interviews. We conclude by offering some recommendations on how to overcome the current situation and how to improve the quality of evacuation preparedness.

2. Theoretical background: evacuation, preparedness and planning

In order to be prepared for a nuclear disaster, the community living in the vicinity of a nuclear power plant needs to develop adequate plans and structures. Evacuation is an important protective action for mitigating the consequences of a disaster, especially if an evacuation can be carried out in time before the disaster strikes, thereby protecting lives and reducing the number and severity of the injuries. In this sense, the evacuation of vulnerable populations is an effective means of reducing the negative consequences of disasters. Crisis management actors regard an evacuation as a generic protective mechanism because it can be an effective response to several types of disasters, including floods, hurricanes, volcanic eruptions, accidents involving hazardous substances as well as nuclear power plant disasters [36]. An evacuation can be considered as a complex psychological and technical (logistic) process which occurs as a result of warnings and/or actual/perceived necessity. It includes the withdrawal of persons from a threatened zone, their temporary sheltering, and their returning home [3]. In the case of severe disasters, the process of evacuation may conclude with the permanent displacement of evacuees.[4]

Drabek [11] identifies different types of evacuations and provides the following classification which takes into account the stage of the announced evacuation and its duration: preventive (before an accident, short-term); protective (before an accident, long-term); rescue (after an accident, short-term); and recovery (after an accident, long-term). Other classifications are also possible since current approaches recognize the existence of different terms, such as a mandatory evacuation, voluntary evacuation, recommended evacuation, declared or undeclared (self-initiative, shadow) evacuation, formal and informal evacuation, horizontal and vertical evacuation, general (mass) or partial, selective and gradual evacuations (see e.g. [11,36,53,5,65,19]).

[3] The IAEA has established international standardized guidelines for countries on intervention and action levels. The generic intervention level for sheltering is an avertable dose of 10 mSv over a period of no more than two days; for temporary evacuation, the avertable dose is 50 mSv over a period of no more than one week; and for iodine prophylaxis, 100 mGy of an avertable committed absorbed dose to the thyroid due to radioiodine. Authorities may wish to initiate evacuation at lower intervention levels for shorter periods, and also where evacuation can be carried out quickly and easily, for instance for small groups of people. Higher intervention levels may be appropriate in situations where an evacuation would be difficult, such as for large population groups, or if there is inadequate transport [22]. At the national level, countries have mostly adopted these recommended intervention and action levels, but with some variations (see [40]). For a measurement of the different levels of nuclear accidents/disasters, the International Nuclear and Radiological Event Scale (INES) can be used. The INES uses a numerical rating to represent the significance of events associated with sources of ionizing radiation. Events are rated on seven levels: 1–3 are 'incidents' and 4–7 'accidents' [59]. The Fukushima accident was graded as a 'major accident—level 7' according to the INES.

[4] The last notorious example of such an evacuation is the case of the nuclear disaster in Fukushima. The *Japan Times* reported on 10 March 2014 that some 267,000 people remain displaced from their hometowns; the vast majority of them continue to live in small temporary housing units or apartments rented for them [46].

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