RADIOACTIVE POLLUTION HAZARD OF THE DANUBE RIVER ALONG THE ROMANIAN REACH

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Abstract: Several aspects are presented regarding the nuclear accident and the irradiation hazard; areas bearing nuclear hazard along the Lower Danube; an example of nuclear accident – the Chernobyl accident and finally the control of the nuclear hazard.
Keywords: nuclear accident, areas bearing nuclear hazard along the Lower Danube; control of the nuclear hazard.

RISIKO DER RADIOAKTIVEN UMWELTVERSCHMUTZUNG DER DONAU IM RUMANISCHEN SEKTOR

Zusammenfassung: Es werden einige Aspekte bezuglich des nuklearen Unfalls und des Risikos der Bestrahlung; Zonen mit nuklearem Risiko in der unteren Donau; ein Unfallbeispiel, Nuklearunfall bei Cernobil und, letzenendes, die Kontrolle des nuklearen Risikos.
Schluesselworte: nukleares Unfall; nukleare Risikozonen; der Fluβ Donau; Kontrolle des nuklearen Risikos.

1.Introduction

The nuclear accident is the event that affects the nuclear installation and/or contamination of the population and of the environment above the admitted limits (according to the definition given by the Republic's Norms for Nuclear Security in Romania).

The potential sources for a nuclear accident are: the energetic nuclear reactors; the installations belonging to the extraction and formation of the nuclear fuel; the installations for treatment of the radioactive offals; the transport and storage of the nuclear fuel or of the radioactive offals; the production, transport, use and storage of the radio nuclides used in certain domains for productive activities, treatment, research; the nuclear tests.

Nuclear reactors are operational along the Romanian section of Danube, displaying potential risk, should accident occur. In this context some aspects are presented regarding the effects of a nuclear accident; the areas hat may be affected by a nuclear accident on the Lower Danube; the way in which the Chernobyl accident took place and some of its effects and finally certain topics of the nuclear control are approached.

2.The nuclear accident and the irradiation hazard

If an accident to a nuclear plant leads to the release of radio nuclides in the atmosphere, the local winds will transport certain radioactive isotopes (gaseous or volatile). Since the radioactive matter behaves like a smoke cloud, it will disperse into the atmosphere partially depositing on the ground, the water surfaces and the vegetation. The concentration of the radioactive substances within the cloud decreases with the distance but traces of radioactive matter might be found far from the accident site. The isotopes of the iodine and of the Kr and Xe noble gases are important in the early stages of an accident. In the late stages, the Cs-137, Cs-134, Sr-90, H-3 isotopes are important. Figure 1 (Ionescu, G., Furnica, G.,1983) renders the circulation of certain radio nuclides evacuated in the environment by a nuclear-electric plant.

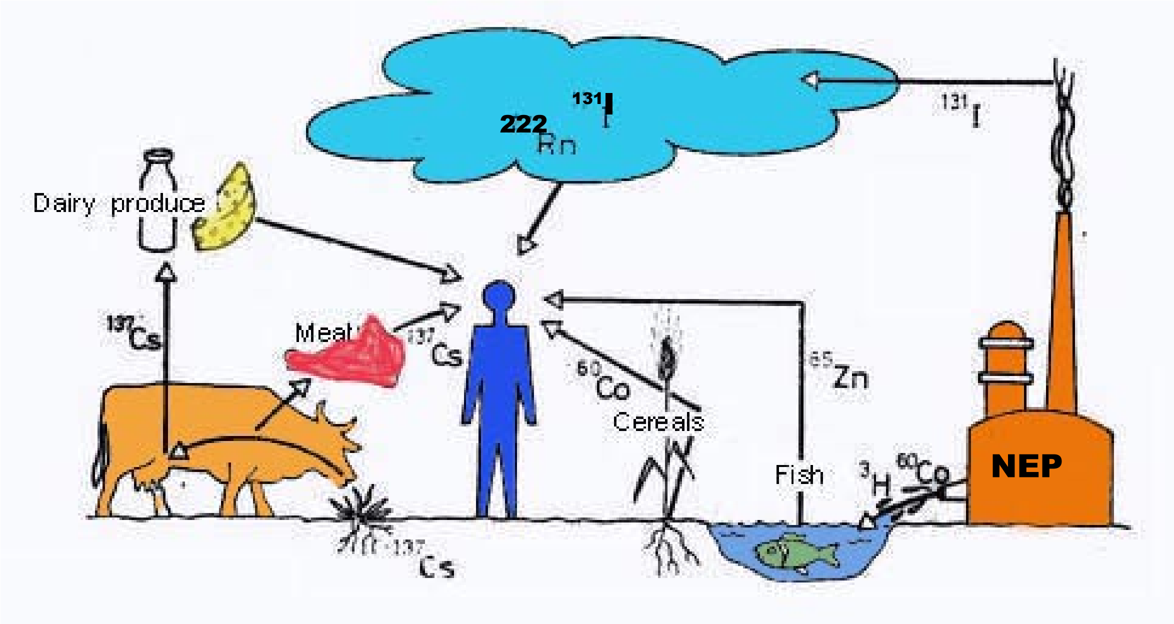


Fig.1. Circulation of certain radio nuclides released in the environment by a nuclear - electric plant (NEP).

The radioactive matter may inflict more consequences on the ecosystems. There are affected: the self-regulating mechanisms of the biocenoses, interactions and composition of the flora and fauna are modified in biocenoses; radio nuclides are accumulated in the compartments of the ecosystems (biotopes and biocenoses) – the accumulation being differentiated function of the chemical affinity.

The radioactive material is hazardous to humans due to the exposition to radiation in three different ways: from external exposition to the radiation emitted by the substances within the wind-led cloud and from the material deposited on the ground; from the internal exposition to radiation through the inhalation of radioactive substances in the air; from possible consumption of contaminated food and drinking water. Function of the total absorbed dose, the effects of the irradiation of the human body is differentiated, as shown in table 1.

Table 1. Effect of total absorbed dose on the human body.

Total absorbed dose	*Effect*
1000 Gy	Death at several minutes from exposure.
100 Gy	Death at several hours from exposure.
10 Gy	Death at several days from exposure.
7 Gy	90 % mortality during the weeks following exposure.
2 Gy	10 % mortality during the months following exposure.
1 Gy	Without mortality, but with significant increase of cancer occurrence.

As result of the existence of these harmful effects, assessments and studies are performed regarding the hazards involved by the use of the nuclear energy, i.e. categories of hazard are estimated, as for example:

- Irradiation hazard: the probability of injuries or human and material loss occurrence, in a reference period and a given area, by a nuclear event,

$$R_i = P_i \quad C_i \qquad (1)$$

where P_i is the occurrence probability of a certain event, and C_i – harmful effect produced by a nuclear accident.

- <u>Collateral hazards</u>: the probability of occurrences that mat induce, contribute to or favour a nuclear event, through the induced effects

$$R_c = P_c \quad R_i \qquad (2)$$

where P_c is the occurrence probability for an event that may cause a nuclear accident.

Events that may cause a nuclear accident are various: earthquakes, construction errors at the nuclear units; manipulation and exploitation errors at nuclear installations; terrorist attacks; nuclear tests wrongly controlled, etc.

- <u>Benefits / hazard analyses:</u> global assessments on both the beneficient effects of using the ionizing radiation and hazards and hazards triggered by their use.

3.Areas of nuclear hazard on the Lower Danube

The areas of nuclear hazard on the Lower Danube are: Dolj county and partly Olt, Gorj and Mehedinti counties, due to the Kozlodui Nuclear Electric Plant (NEP); the area Constanta, Ialomita and Calarasi counties, due to the Cernavoda NEP. These areas are schematically rendered in figure 2. (Chiosila, I., 1998).

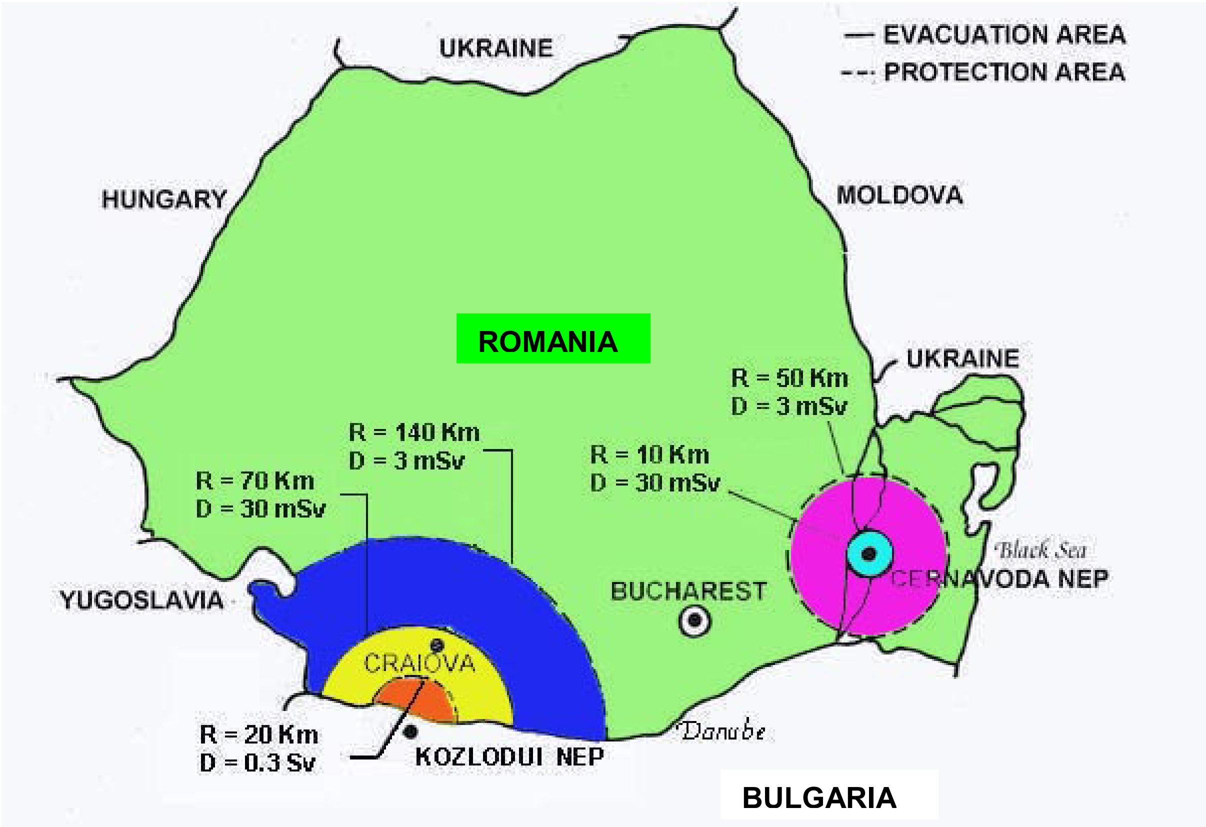


Fig. 2. Areas of nuclear hazard.

3.1.Characterization of the Kozlodui NEP area

<u>Site.</u>

The Kozlodui NEP is sited in the vicinity of Orahovo City, on the right bank of the Danube, near the Kozlodui islet. The populated rural areas are situated at distances varying between 9 and 30 km from the source.

<u>Kozlodui NEP structure</u>

The Kozlodui NEP is made of an ensemble of six nuclear reactors, four of which PWR (Power Water Reactor) – type light, pressurized water. Those reactors are unenveloped,

having a power of 440 Mwe, the nuclear fuel used is enriched uranium. The other two reactors have a power of 1000 MWe and are enveloped.
The first reactor became operational in 1974.

Possible impact on the environment

The radioactive pollution may occur in two distinct ways:

- within a 30 km radius semicircular territory, the environment contamination posibility exists because of the gaseous offals that might be released into the atmosphere;
- within a territory of approximately 80 000 ha belonging to the Kozlodui NEP, the environment contamination possibility exists because of the offals that might be released.

The biotopes that might be affected by a possible radioactive pollution are:

- a plain biotope, characterized by an altitude of 100 m.a.s.l. (corresponding to the semicircular area around the plant), with a prevalence of the south-eastern and south-western winds – a possible radioactive pollution may occur through the atmosphere;
- a sands biotope existing in the area the irrigation canals, characterized by an altitude of 75 m.a.s.l.; the radioactive pollution may occur through the irrigation waters originating in the Danube radioactive offals discharge.

Figure 3 (Prunariu, L., Peteu, Gh., 1995) renders the scheme of the possible impact on the environment in the Kozlodui NEP area.

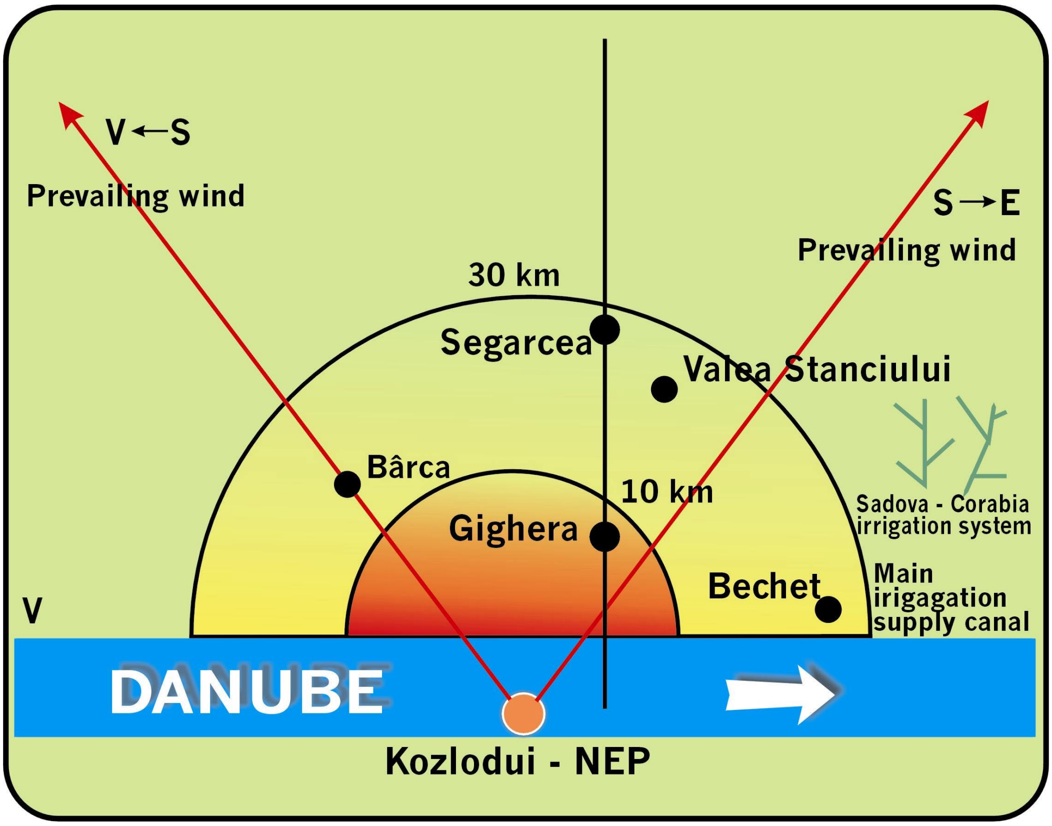


Fig. 3. Scheme of the possible impact on the environment in the Kozlodui NEP area.

Population.

The population is grouped at the level of the Bechet, Ostroveni, Gighera and Valea Stanciului localities. The population group totaled 63 901inhabitans in 1995. This population group may enter the influence of a radioactive contamination in various ways (atmospheric accretions, rain water, water from the Danube, etc.)

Possible hazard.

In the case of a nuclear accident, the south of Dolj county is affected
(a hemisphere 20 km in radius from the Kozlodui NEP) and the nearest localities
(Bechet and Gighera), where the exposition dose may reach 300 mSv.

3.2.Characterization of the Cernavoda NEP

Site.

The Cernavoda NEP is placed in the Danube – Black Sea, canal which is 64.4 Km long and connects the Cernavodă river port, at Km 299.5 on the Danube to the Constanța-Sud, Agigea and Midia port from the Black Sea. The canal's river bed is 90 m wide and 7 m deep.

Structure of Cernavoda NEP.

The type of reactor within the Cernavoda NEP is CANDU (CANadian Deuterium Uranium) – a Canadian enveloped reactor type, the moderator is hard water and the fuel used is natural uranium (figure 4, Chiosila, I., 1998). The first reactor has become operational in 1996.

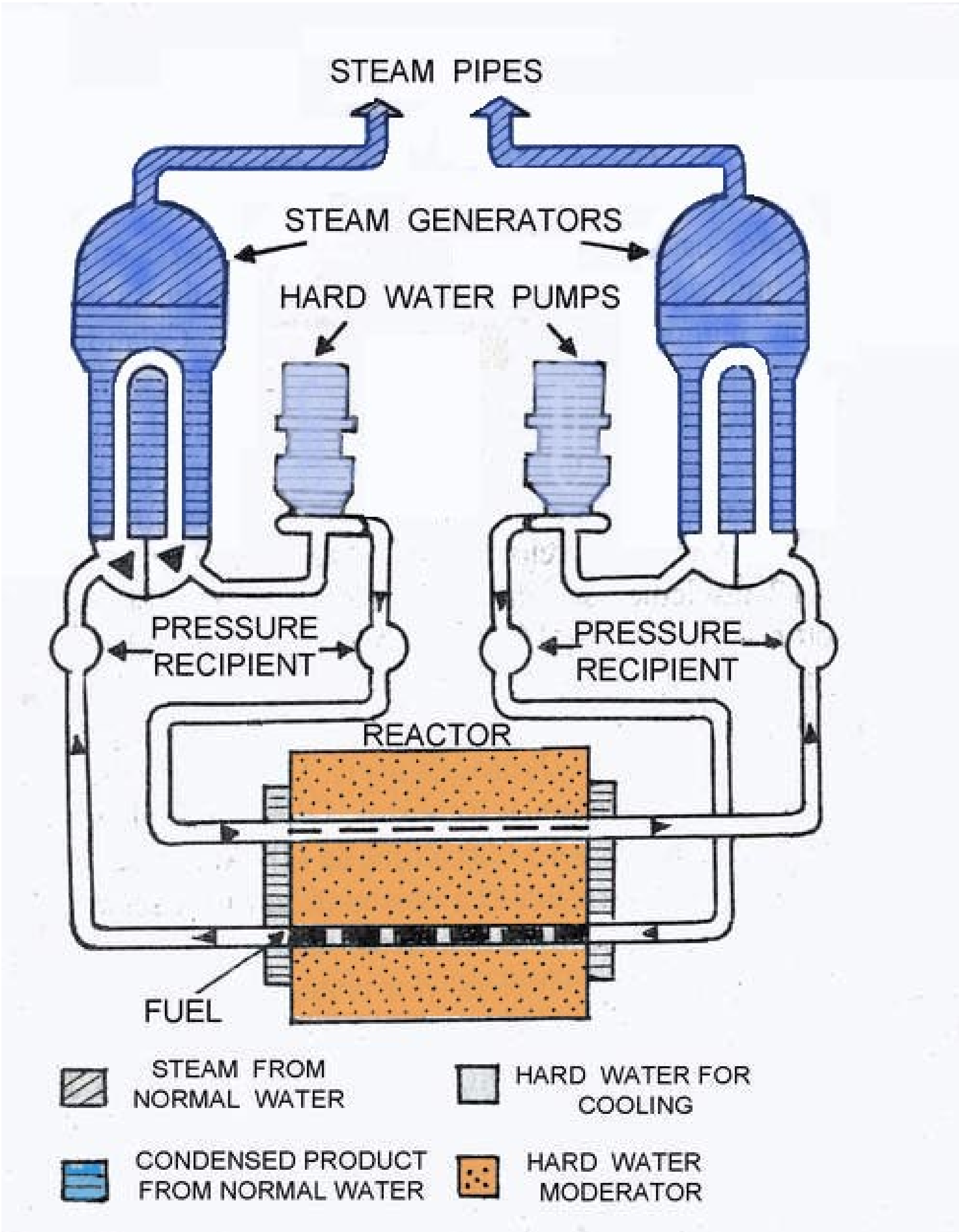


Fig. 4. Scheme of Cernavoda NEP CANDU reactor

Impact on the environment.

In normal functioning conditions of the CANDU system, one of the released radio nuclides is tritium (T_f = 12.3 years). The normal releasing level of tritium is from 10^{11} Bq / MWe during the first year of operation and 7×10^{11} Bq / MWe from the second year on. In normal functioning conditions of the NEP, the values of the tritium and of other radio nuclides' concentration stay below the maximum concentration allowed by the radioprotection norms.

Population.

At the February 1992 census the population was 22 522 inhabitants. Their main activities are the limestone, lime, plaster extraction and the cement production.

Possible hazard.

In case of a basic accident within the design (loss of the cooling agent coupled with the partial unavailability of the cooling systems, but with intact envelope) the population neighboring the NAP will receive an all-body effective dose of maximum 0.027 move - a value one length order below the maximum dose allowed to the population. If an accident with envelope deterioration occurs, the area immediately contaminated is a 10 km - radius sphere, with a 3 move dose. Offals from the Cernavoda NEP are stored in a local storehouse in NAP perimeter for 10 year time, to be further transferred into an intermediate storehouse for 50 - time. Later, offals are designed to be transported to a definitive storehouse (stable storage).

4. An example of nuclear accident - the Chernobyl accident

The sequence of events connected to the Chernobyl accident was the following:

- On the night of 25 / 26 April 1986, the operational staff, breaching the operation norms and wishing to carry out an experiment, lowered the rector's power to 10 % of its installed power.
- The return to normal was impossible and the power of the reactor increased abruptly to hundred of thousands of MW in just two seconds.
- The temperature increased fast in the active area, which led to the impossibility of stopping the reactor. (The slots for lowering the control bars were distorted because of the high temperature, which made them unusable and caused the fission reactions to continue).
- There occurred two successive nuclear blasts at an interval of several seconds, which blew up the 1000 t - protective concrete plate on top of the reactor, as well as large amounts of nuclear fuel loaded with fission radio nuclides. The graphite moderator caught fire and burned some two weeks.
- 135 000 people were evacuated from the area; their external irradiation collective dose was estimated to 1.6×10^4 person - Sievert (person - Sv), (AIEA Bulletin, 3 / 1996).
- The radioactive material released following the nuclear explosion contaminated vast surfaces, with up to 30×10^5 Be / m^2, (AIEA Bulletin, 3 / 1996).
- The total worldwide impact of the Chernobyl accident was estimated to 600 000 person - Sv, equivalent on the average to 21 supplementary days of the world exposure to the natural radiation background, (AIEA Bulletin, 3 / 1996).

5.Nuclear hazard control

The ionizing radiation may act such that the cells of the living organisms modify or deteriorate in time, function of the radiation dose equivalent, immediately, or in time.The possible ways of exposure to radiations are schematized in figure 5 (Popescu, V., et al.,1990).

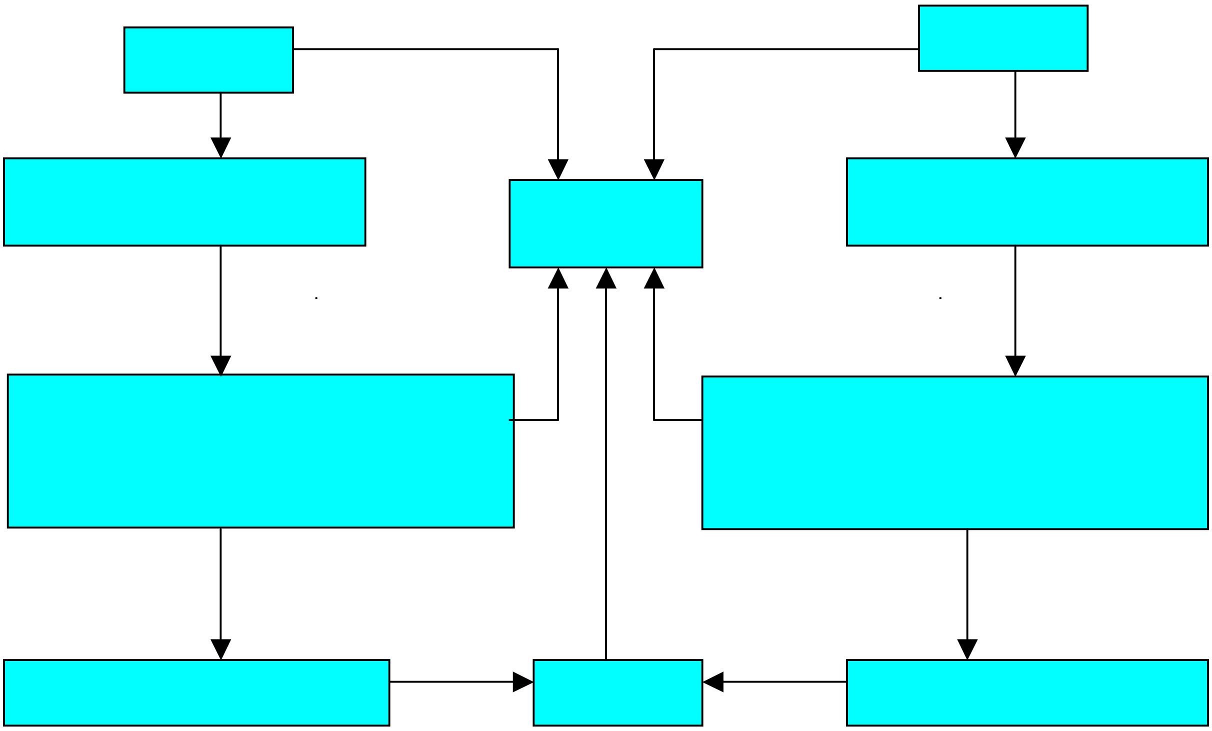


Fig. 5. Possible ways of radioactive irradiation

Therefore, control must be imposed of the nuclear (or irradiation) hazard. This takes place in a legal framework, through a series of prevention, protection and intervention measures, to be achieved by stages and variants, function of the concrete situation (table 2, Moisescu, M.,et al., 1994).

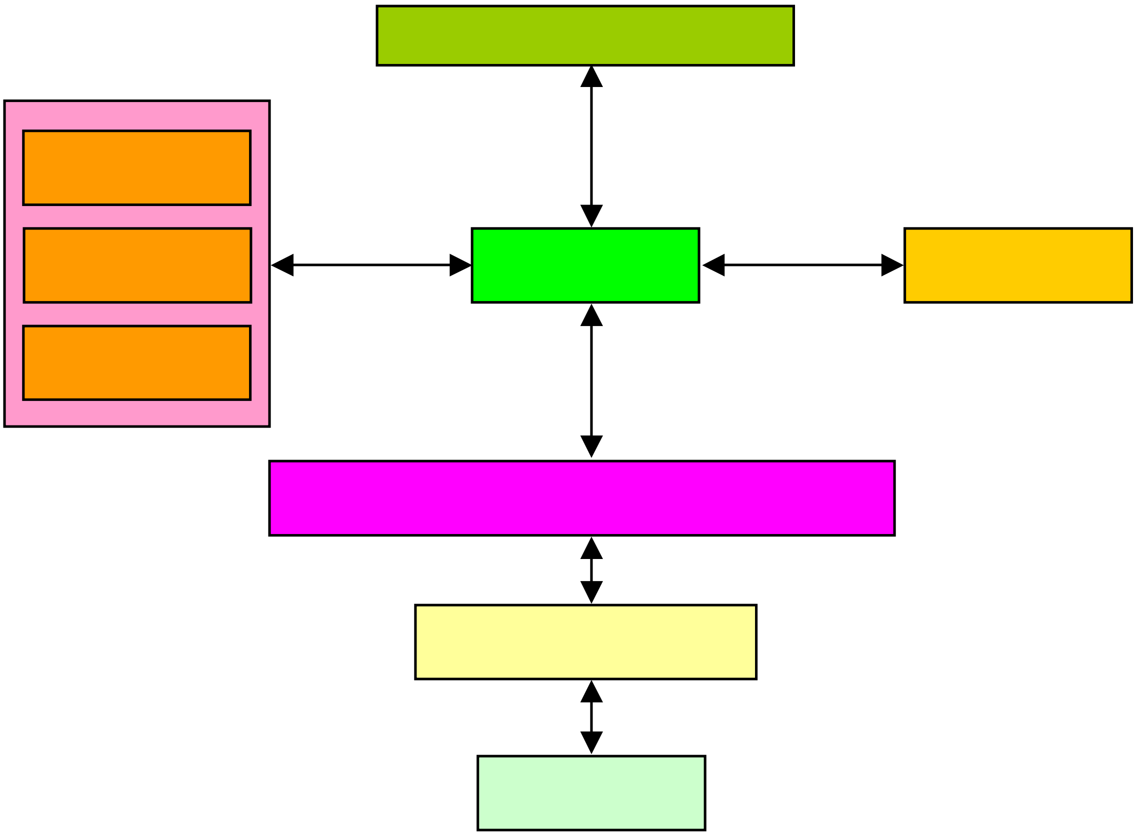
Table 2. Time scale of a nuclear accident

Phase of nuclear accident	*Duration*	*Hazard*
Initial.	Several hours since accident debut.	Inhalation of radioactive material and / or irradiation due to the radioactive cloud.
Intermediate.	From several days to several weeks since initial phase.	External and internal irradiation because of radioactive accretions, as well as inhalation and ingestion of contaminated matter.
Final.	From several weeks to several years since initial phase (depending on the nature of the radioactive releases).	Ingestion of contaminated food. Contamination of the environment.

During the phases of the nuclear accident, various protection measures are applied, as for instance: notify and warn the population; monitor and control radioactivity; research of the radiation; sheltering; prophylaxis; protection of the animals of the water sources, the agricultural and food products and of other goods; evacuation of the population; dosimetric control, emergency medical assistance supply; restrictive measures concerning the water and food consumption; decontamination of the population and of the affected areas;

collection, transport and storage of the concentrated radioactive products, of the food and other goods dangerously contaminated radioactively.
The existence of certain nuclear activities (i.e. the existence of the nuclear-electric plants along the Danube as well as the energetic nuclear reactor in Pitesti) imposed the necessity to implement the RODOS (Real-time On line DecisiOn support System) in Romania. That is a system for monitoring of the environment factors and of the environment radioactivity in real time. Starting with 1995, the basic equipment to the RODOS project (the HP 735 Graphic Station) is being purchased and installed at IFIN-HH, along with the PRTY soft for HP 735 GS in November 1997 (Mateescu, Gh.,et al.,1998).
Also there are being implemented data in various modules of the system (for instance METEO,HYDRO from the National Company "National Institute of Meteorology, Hydrology and Water Management"). The general scheme of the RODOS ensemble is rendered in figure 6 (Mateescu, Gh.,et al.,1998).

Designed configuration of the RODOS SYSTEM. (Mateescu et al., 1998)



ASY – the analyzing subsystem
CSY – the countermeasure subsystem
ESY – the evaluating subsystem
OSY – an operating subsystem
SSY – a supervising subsystem

Fig. 6. General scheme of the RODOS system.

6.Conclusions

- The use of the nuclear energy also means the possibility that accidents occur, as for instance explosions and fires inside the occur, as for instance explosions and fires inside the nuclear reactor and the melting of its core, contamination of environment with radioactive isotopes, loss of cooling water, loss of radioactive sources or offals during their transportation, etc. Therefore, using the nuclear energy implies the existence of hazards (irradiation and collateral hazards, respectively, for which reason benefit / hazard analyses are always performed.
- The nuclearly hazardous areas along the Lower Danube are: Dolj county and partly Olt, Gorj, Teleorman and Mehedinti counties, because of the Kozlodui NEP, situated south of the Danube, in Bulgaria, consisting in four 440 MWe unenveloped reactors and two enveloped reactors; the area of Constanta, Ialomita and Calarasi counties – because of the Cernavoda NEP, in Romania, operating with a 700 MWe enveloped CANDU reactor.
- The control of the nuclear hazard is performed by stages and variants, function of the nature of the nuclear accident. A system for the monitoring of the environment factors and radioactivity in real time is the RODOS system.

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