DECISION SUPPORT SYSTEMS AND NUCLEAR EMERGENCY EXERCISES – HYDROLOGICAL IMPACT ASSESSMENT

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Lucrarea prezintă câteva aspecte relevante în sprijinul deciziei pentru managementul urgenţei radiologice. Se utilizeaza două sisteme de evaluare – RODOS (modulul – HDM) si MOIRA pentru evaluarea impactului radiologic în reteaua hidrografică. Se prezinta unele rezultate privind evaluarea concentraţiei de radionuclizi în apa şiîin peştii prădători/neprădători. Sunte scoase în evidenţă rolul şi ponderea pe care o acordă Apărarea Civilă şi autorităţile de reglementare pentru sistemele de sprijin a deciziei în raspuns la evenimentele nucleare deosebite.

The paper presents several aspects relevant in the decision support for management of radiological emergency The two assessment toolkits are used – RODOS (HDM – module) and MOIRA for evaluation of radiological impact in hydrological network. Some results concerning the assessment of radionuclide concentration in water and in predatory/prey fish are presented. It is outlined the effective role and weight that tends to be retained, in actual practice, by Civil Defence and regulatory authorities for decision support systems in the response to abnormal nuclear events.

Keywords : Decision support systems, emergency exercises, radioactivity

1. Introduction

One lesson drawn from the Cernobyl accident has recognized the importance to develop comprehensive decision support systems for radiological emergency management and their use during emergency exercises. Two exemplary cases are discussed – the CONVEX 2005, international alert exercise targeting a CANDU reactor at Cernavoda nuclear power plant in Romania, and Oltenia 07 – a national-wide drill around a scenario involving transborder effects from a VVER reactor at Kozloduy, Bulgaria. Two assessment toolkits are used – RODOS (HDM – hydrological module) and MOIRA, adapted and customised to Romanian conditions for evaluation of radiological impact in hydrological

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network. Some tests of functionality for the two mentioned systems were done at University Politehnica and the exercises were supported at National Institute for Physics and Nuclear Engineering (NIPNE).

Seen from NIPNE and Politechnica perspective, the CONVEX-3 theatre of action featured (a) the RODOS server, located on the Institute's working station, and MOIRA system operating on a PC, (b) the RODOS remote operator, on duty at National Emergency Response Centre, downtown Bucharest. Oltenia 07 relates to the organization, by the Romanian General Inspectorate for Emergency Situation, of an emergency drill to test near-site capabilities, in the case of transborder accidental release at the Kozloduy NPP, on the Danube river.

During the exercises, some particular requirements were expressed regarding the impact assessment of radioactive release on hydrological network, especially on the Danube river.

The evaluation had two steps:

STEP1: The evaluation of radioactive peak arrival following the deposition on water surface at some cities situated on Danube river side. The evaluation was made by using RODOS – HDM (hydrological module) estimation and the early time estimation of concentration in water for Cs-137 and Sr-90.

STEP2: The evaluation of concentration in fish and water for long period (months, years) due to the deposition and radionuclide migration from the catchment by using MOIRA system.

The accident's Day-1 in CONVEX-3 exercise a first release reportedly occurring at 6:30 hours. The source term was provided by NPP Cernavoda and consisted of 10 radionuclides: H-3, Kr-83m, Kr-85m, Kr-85, Kr-88, Kr-89, Xe-133m, Xe-135, Xe-135, Xe-138, I-131, I-132, I-133, I-135, Cs-134, Cs-137 and Cs-138.

The meteorological scenario for the first hours into the release has presumed that wind direction is towards the city of Cernavoda, to favour the deployment of intervention forces in the field and mobilisation of population as a a part of the drill.

In the case of OLTENIA-07 the meteorological scenario has presumed that the wind direction is toward the city of Bechet to test local capabilities to mitigate accident

release consequences. The Kozloduy scenario employed a modified reference source term for a VVER 1000 reactor – available in the data base of RODOS system.

2. Early and Late Countermeasure Computing Systems.

RODOS (Real Time on-line Decision Support System) [1], [2] is a comprehensive software package developed by a consortium of European research

institutions, and promoted by EC as a reference DSS. The system covers the early (1-7 days) as well as the intermediate and long (ingestion) phases (months, years) in the development of an accidental release, with health, environment and economic consequence consideration. The RODOS system includes HDM module [3] covering the relevant transfer processes in the hydrosphere. In HDM module the Saint-Venant equations are used for one-dimensional water flow modelling:

$$\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=q_l$$
$$\frac{\partial Q}{\partial t}+\frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right)+gA\left(\frac{\partial h}{\partial x}+S_f\right)=0 \quad (1)$$

Where:
Q – water discharge (m^3/s); A –water sectional area (m^2); q_l –water discharge of lateral inflow (m^2/s); S_f – friction slope of water flux; h –water depth (m)
g – gravitational acceleration (m/s^2)

MOIRA [4] is a Model - computerised system for management support to Identify optimal strategies for restoring Radionuclide contaminated Aquatic ecosystems and drainage area. The system is applicable for the definition and analysis of a variety of appropriate strategies for the long-term management of contaminated freshwater bodies. MOIRA predicts the medium and long term transport process within the river ecosystems by the assessment of the input-output balance of water flowing to and from each reach. The model subdivides the river in 20 reaches.
The two systems working simultaneously had several merits:

(i) An opportunity was provided, to check the validity of several working assumptions and postures adopted over the years by NIPNE in nuclear emergency preparedness.
(ii) It was confirmed by various authorities and expert parties that RODOS and MOIRA are indeed a viable and functional decision support systems (DSS).
(iii) The reaction of the stakeholders – mainly in Civil Defence has clearly evidenced that, beyond the knowledge of the pollution of water following the deposition of radionuclides due to air convection and diffusion, there is a need for dose estimation assessment, countermeasure design, consequences and mitigation cost determination.

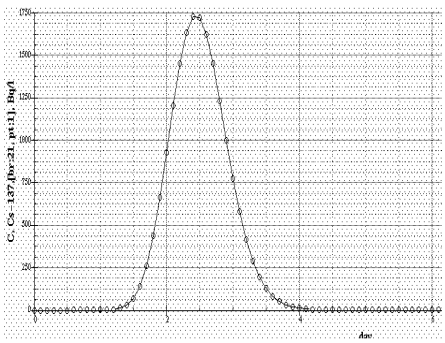
3. Results

RODOS system was customised only to Cernavoda conditions and was used in CONVEX-3 exercise, [5], but MOIRA system was customised for all Romanian segments of the Danube and used for both exercises.

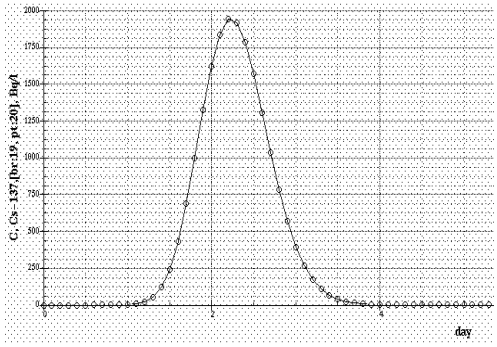
The first information required by decision makers has targeted the arrival of radioactivity peak for Cs-137 due to deposition of the radionuclide on and near the Danube river and if the concentration in water is harmful or not. Fig.1-3 present the RODOS-HDM results regarding the concentration and peak arrival on main cities (Braila, Galatzi, Tulcea) downstream Danube.

For the evaluation of medium and long contamination of freshwater bodies, basically lakes, reservoirs and rivers, MOIRA DSS was chosen. Fig.4 and Fig.5 present the results of Cs-137 concentration in water, prey and predatory fish due to migration of radionuclide through catchments and the absence of countermeasures in the first months of deposition. The results are obtained on Danube segment near the Cernavoda NPP and Kozloduy VVER NPP, respectively.

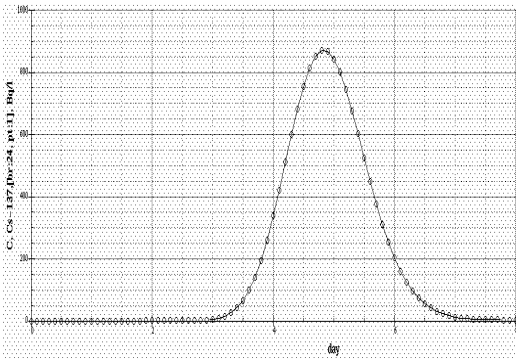
In CONVEX-3 exercise the analysis of the results shows the ban of river water use but the predicted concentration of Cs-137 in fish is below the normative levels and no countermeasure had to be taken, in contrast with OLTENIA 07 [6], where the fish ban was advised. Another important result of RODOS concerned the evaluation of the radiological impact of tritium – a nuclide expected to abound in releases from CANDU reactors like one at Cernavoda.



Braila



Galatzi



Tulcea

Fig.1-3 RODOS-HDM results regarding the concentration and peak arrival

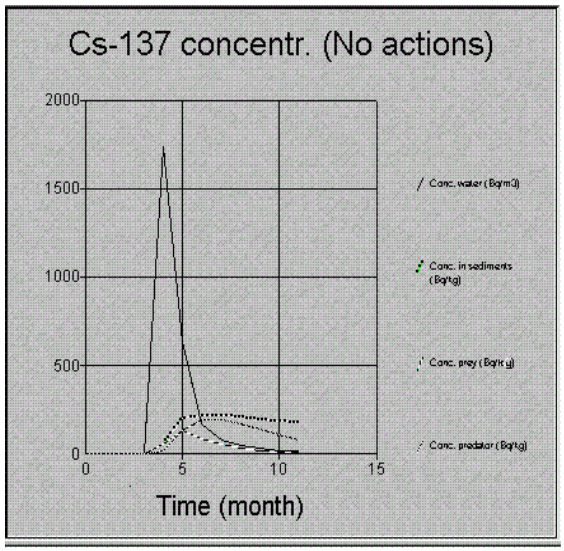


Fig.4 Concentration in predatory/prey fish CONVEX-3 – exercise (MOIRA)

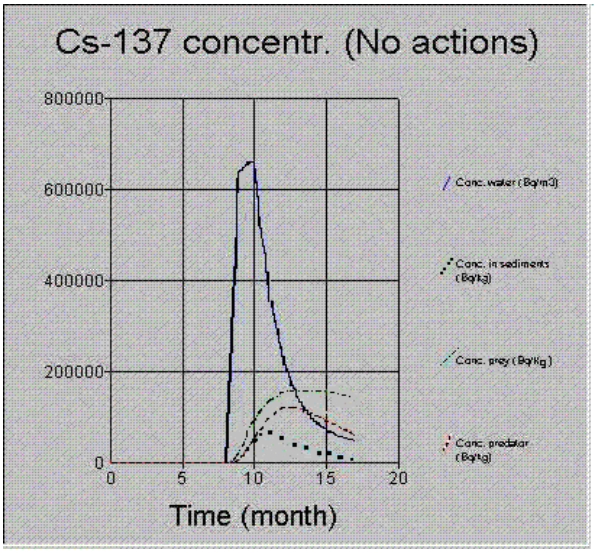


Fig.5 Concentration in predatory/prey fish OLTENIA 07 – exercise(MOIRA)

4. Conclusions

Drill debriefings have confirmed:

(i) The effective role and weight that tends to be retained, in actual practice, by Civil Defence and regulatory authorities for decision support systems in the response to abnormal nuclear events.

(ii) The complementary between the two DSS, RODOS and MOIRA, developed and customised for national compatibility

(iii) The merits of employing expert systems to avoid stress and psychological pressure, confusion or mistake decision in the early and long phase of emergencies

(iv) Even the impact on hydrological network follows the atmospheric release the information regarding radionuclide concentration in river and other freshwater bodies is essentially in taking the suitable countermeasures to mitigate the accident consequences.

(v) The proper implementation of DSS systems requires that a lot of environmental and socio-economic data to be collected. The operational use may require that data to be prepared ahead and updated.

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B I B L I O G R A P H Y

[1] *M. Rafat, W. Raskob and T. Schichtel*,: Concept of outline of the redesigned of RODOS EURANOS, **CAT-2-TN06-01**, Jan 2006

[2] *W.Raskob and J.Ehrhardt*, The RODOS System: Decision Support for Nuclear Off-site Emergency Management in Europe. 10th International Congress of the International Congress of the International Radiation Protection Association (**CD published,** May 14-19, 2000. Hiroshima, Japan), 2000

[3] *Ya. Sorokin, G. Donchits, A. Popov*, HDM user guide, **RODOS-WG4-TN(99),19**, 1999

[4] *M.Magan, and E.Gallego*,. Application of the MOIRA DSS to evaluate rehabilitation strategies for contaminated freshwater bodies at the local and regional levels. **EURANOS(DEM) – TN(06)**.,2006

[5] *D. Slavnicu, D. Vamanu, D. Gheorghiu, V. Acasandrei, B. Vamanu*, Convex-3: A case of flexible strategies, in nuclear emergency management, Proceedings of 11th Int. Conference on Harmonization within Atmospheric Dispersion Modelling for Regulatory Purposes, pg.91-95, 2007

[6] *D. Slavnicu, D. Vamanu, D. Gheorghiu, V. Acasandrei, B. Vamanu,* Decision Support systems and emergency response exercises – lessons and issues , Proceedings of Int. Conference on Radioecology & Environmental Radioactivity, pg.150 – 153, 2008