Journal of Hazardous Materials 61 (1998) 381–384

JOURNAL OF HAZARDOUS MATERIALS

# PRANA: geoinformation decision support system for protection and rehabilitation of agrosphere after nuclear accident

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**Abstract**

The description of the computer system PRANA DSS (Decision Support System for Protection and Rehabilitation of Agrosphere after Nuclear Accident) for analysis of protective measures in the long-term period after a nuclear accident is presented. The development of PRANA DSS is based on the use of geoinformation technologies and elaboration of approaches and methods of estimation of the consequences of the Chernobyl accident. The features of the system and its components are briefly considered. © 1998 Elsevier Science B.V. All rights reserved.

*Keywords:* Geoinformation system; Decision support system; PRANA; Protection and rehabilitation; Nuclear accident; Radioactive contamination; Map of landuse; Population doses; Avertable doses; Countermeasures; Countermeasure effectiveness; Cost–benefit analysis

## 1. Introduction

After the Chernobyl accident a series of models and computer systems for estimating the consequences of a nuclear accident was developed [1]. Taking into account that the computer systems mentioned were intended only for solving specific tasks in the acute and/or long-term periods after an accident, the development of computer DSS was continued with regard to new approaches, models and data, including a wide class of countermeasures. The developments were based on the use of up-to-date computer technologies and on the requirements of the applied systems (the use of a geoinforma-

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*PII* S0304-3894(98)00147-2

tion system, up-to-date database management systems and systems for the analysis of decision making). In this connection, first of all, the RODOS Project/System (real-time on line decision support system) should be noted [1].

## 2. The structure and features of PRANA DSS

### 2.1. The objectives

The PRANA is a decision support system on countermeasure management in the agrarian sector during the long-term period of liquidating the consequences of a nuclear accident (when external and internal irradiation from long-lived radionuclides and root uptake of radionuclides into plants are the main dose formative factors). The PRANA DSS is intended for solving the following tasks: estimation of the structure of contamination of agricultural production; assessment of the structure of internal and external doses for (rural) population; estimations of the results of application of a wide class of countermeasures on decreasing the contamination of agricultural products and/or population doses; evaluations of countermeasure effectiveness with the use of radiological and economic methods; comparison of different alternatives/protective strategies (agricultural countermeasures, restrictions on local foodstuff) with the possibility of changing/analysing various intervention levels; and decision making support on management of contaminated territories.

### 2.2. Features of PRANA DSS

The PRANA DSS consists of the system core and the set of applications (modules). The core is responsible for loading initial data, electronic maps, mathematical models, libraries of presentation and data access. Applications are intended for solving specific tasks, including analysis and presentation of source data, estimation of the consequences of land contamination, assessments of the results of implementation of countermeasure systems and comparison of different intervention strategies.

The features of the PRANA DSS are the following characteristics: the use of GIS-technologies; vector *map of landuse* and associated database are key components of the system; different levels of investigation and information detailing when estimating the consequences of land contamination, implementation of protective measures and evaluation of their effectiveness (district, farm, (settlements), arable lands, natural lands); particular attention is given to agricultural countermeasures; assessments of countermeasure effectiveness are based on the use of economic and radiological methods (including different variants of cost–benefit analysis); the use of random/distributed methods for analysis of uncertainties or inhomogeneous character of population doses and contamination of agricultural production.

### 2.3. Input information

Database is one of the components of the PRANA DSS with information on radioactive contamination, agricultural production, settlements, etc. (these data are consistent with the map of landuse), as well as information on various radioecological and agroecological data and parameters of models. Input information indicated is divided into several types. Geographical data (GIS layers) include electronic maps of surface contamination density of territory by radionuclides, maps of landuse (settlements, arable lands, pastures, hayfields, forests, water systems, etc.), soil types, boundaries of the administrative division (farms, districts, regions). 'Tabular' information includes data on radiological parameters as well as agroecological, economic, demographic and other ones, including various transfer factors (for plant-growing and animal husbandry production) and countermeasure characteristics [2,3], demographic and agroecological data (yields, current land use, crop rotations), monitoring data (including physical and chemical characteristics of agricultural lands, internal and external population doses for settlements, local rations).

### *2.4. Protective measures*

A wide class of countermeasures (CMs) is implemented in the PRANA DSS which can be divided conditionally into agricultural and administrative ones. Agricultural CMs include various measures for natural and arable lands, CMs in animal husbandry and management in agroindustry [2,3]. Administrative CMs comprise restriction/ban of local foodstuffs, restrictions of population activities and relocation; among them there is a possibility of intervention levels alteration that can change significantly the structure and scale of intervention measures and lead to the change of the structure of population doses.

### *2.5. Models and algorithms*

For estimations of agricultural products contamination the models of contamination of plant-growing and animal products are used. The feature of the dose models is a significant use of cartographic data for connecting (rural) settlements with object of landuse (pastures and hayfields, arable lands, forest) and subsequent calculation of contamination of local rations, internal and external doses. Doses for the year chosen and dynamics of doses for each settlement are estimated. Evaluations of countermeasure effectiveness are based on the use of algorithms of estimating avertable collective and/or individual doses, algorithms of assessing countermeasure cost with implementation of cost–benefit analysis [3].

### *2.6. Decision making support*

For the analysis of CMs or countermeasure system/combination the results of their application (contamination of production, population dose, the effectiveness of CMs) are presented as maps, tables, diagrams and graphs for the chosen level of investigation. The following criteria are considered for assessments of countermeasure effectiveness: cost of countermeasures ($P_c$); avertable collective doses ($\Delta S$) as well as avertable collective and individual doses for local population; cost of the unit of collective dose avertable (cost-effectiveness, $e = P_c/\Delta S$); total detriment before and after countermeasures ($Z =$

$P_c + Y$, $Y = \alpha S$, where $S$ is collective dose, $\alpha$ the cost equivalent of the unit of collective dose); net benefit ($B = \alpha \Delta S - P_c + B_a$, where $B_a$ is an cost equivalent of additional benefit associated with countermeasure implementation).

### 2.7. PRANA procedures

The interface of the PRANA DSS allows to use possibilities of modules developed for visualisation of source data, carrying out different assessments and their analysis (zoning and ranking of lands, settlements and farms according to a criterion chosen), the estimation of different CMs and formation of various scenarios for subsequent analysis and decision making. Presentation of output information comprises all results on estimations of production contamination, structure of population doses and countermeasure effectiveness as well as integration of estimates from initial areas (field, settlement) up to the farm or group of farms chosen and district/region as a whole. Operation in the regime of ‘local level’ (at the level of separate farm) provides a more flexible use of PRANA possibilities on implementation and assessment of countermeasure scenarios and presentation of output information.

## 3. Conclusions

The prototype of PRANA DSS developed with the use of up-to-date geoinformation technologies is intended for analysis of protective measures in agrosphere during the long-term period of liquidating the consequences of a nuclear accident and provides computation and integration of main values and criteria.

## Acknowledgements

Development of the PRANA DSS is carried out within the ISTC project #150.

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