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DECISION-MAKING SUPPORT ON RISK BASED LAND MANAGEMENT AND REHABILITATION OF RADIOACTIVE CONTAMINATED TERRITORIES

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Рассмотрены общие методологические вопросы поддержки принятия решений по управлению загрязненными территориями на основе анализа рисков. Представлены характеристики и возможности прикладной геоинформационной системы поддержки принятия решений *PRANA*, разрабатываемой для задач управления рисками и реабилитации радиоактивно загрязненных территорий.

RISK BASED LAND MANAGEMENT AND DECISION SUPPORT

For the last two decades expanses for clean-up and restoration of technogenic contaminated sites and territories increased essentially [1]. Contaminated land regulation can take place at national, regional and/or local levels in accordance with scale of contamination and significance of consequences for the population, environment, economics and other indices.

Land is considered contaminated when there is a risk of unacceptable harm from pollutant during its present or intended use. In scientific and technical terms contaminated land can impact on human health, quality of surface and groundwater, nature and viability of ecosystems, buildings and other materials and artefacts within the ground, and the visual amenity of an area. Each type of accident/technogenic pollution requires of a special approach to clean-up and restoration/rehabilitation of contaminated site/territory. However, some common approaches to decision-making support and general methodology on development and implementation of Decision Support Tools/Systems (DST/DSS) can be used for optimisation of clean-up and rehabilitation of contaminated territories [2].

Decision Support can be defined as the assistance for, and substantiation and corroboration of, an act or result of deciding; typically this deciding will be a determination of optimal or best approach. The decision-making process for any problem usually encompasses: an identification phase of the problem(s), a development phase in which possible solutions/scenarios are identified and developed, a selection phase (a choice of the solution(s) to be implemented).

Several «layers» of decision support can be distinguished: the input information, tools to assist particular decision-making issues, and the overall system in which decision making is applied. The nature of the product for decision support may be different and includes the following: written guidance, flow charts, model procedures, software system (with

different levels of complexity, including problem specific computer modules/systems, GIS, DSS). Decision support integrates specific information about a site and general information such as legislation, guidelines and know-how, to produce decision-making knowledge in a way that is transparent, consistent and reproducible.

The functional application to contaminated land management describes whether the decision support is for risk management, remediation, monitoring and aftercare, sustainable development etc. In practice, a number of DSTs address multiple decision criteria. DSSs may be used for problem identification, site investigation, risk assessment, risk management, aftercare, monitoring, evaluating wider impacts (environmental economic etc), and for sustainability appraisal.

The decision-making role of DSSs implementation describes the type of decision making being supported, *e.g.*: identification of problem(s), specific model estimations for further analysis, prioritisation, comparison of options, strategy development (policy, site specific). Depending on the size and prominence of the site/territory the principal stakeholders in land remediation and appropriate decision-making support can include several of the following: land owners/problem holders; regulatory and planning authorities; site users, workers, visitors; financial community (banks, lenders, insurers); site neighbours (tenants, dwellers, visitors); campaigning organisations and local pressure groups; consultants, contractors and technology vendors; and possibly researchers.

Several different methodological approaches/techniques can be employed to assist environmental decision-making. As a rule, advanced DSS includes/combines some of the following approaches for decision-making support: various aspects of risk assessments, Cost Benefit Analysis (CBA), Multi-Criteria Analysis, Life Cycle, and Sustainability appraisal. Decision making for risk management can be more complex, as it must encompass a range of additional criteria, for example: identification and comparison of different remedial options, a comparison of costs and benefits, and an assessment of risk management performance.

Risk assessment principles are generally based on the *Source-Pathway-Receptor* paradigm. The nature of this linkage controls the degree of risks. Typically the receptors considered are: humans, water resources, ecosystems and other environmental endpoints.

A key component of many DSSs for contaminated land risk management are electronic maps and elements of Geographic Information System (GIS). These tools are not only suitable for presentation of spatial input/output information, but also are irreplaceable means for setting and assessing different scenarios, where spatial structure, geometry of polygons and their positional relationship play a key role (spatial analysis, class of transportation problems, analysing scenarios with consideration of distance and area and temporal functions when assessing risk indices, etc.).

Globally, a number of DSSs are available to identify remediation approaches for particular contaminated site problems, and using site specific information [1-3]. These tools tend to be based mainly on risk management performance and cost considerations. However, some tools are under development to take into account broader constraints (broader economic and environmental impacts, administrative issues, social impacts and risk perception). Nevertheless, the practical use of DSSs in contaminated land risk management planning is surprisingly limited.

RBLM ON THE BASIS OF *PRANA DSS*

Geographic Information System (GIS) *PRANA* is a Decision Support System for countermeasure analysis (in agrosphere first of all) and rehabilitation of radioactive contaminated territories in the long-term period of liquidating the consequences of a nuclear accident. Conceptual requirements to GIS-DSSs meet all the main demands to DSSs for

practical use, research and training on rehabilitation of contaminated territories [3, 6]. Realisation of the planned requirements and tasks are achieved through developing several GIS-DSSs - family of *PRANA* systems, each of them is intended for analysis of specific range of problems:

- GIS-DSS for practical use (with introduction at appropriate Ministries and Centres for decision-making support on rehabilitation of radioactive contaminated territories of Bryansk region on regional and local levels);
- GIS-DSS for research and for scientific and practical estimations;
- GIS-DSS for training and education;
- elements of distributed system and remote access to components of GIS-DSS.

The following sections, which have been realised in accordance with the chosen level of the system, represent in the aggregate a basis of each GIS-DSS indicated above:

- libraries of electronic maps (including different layers of *vector maps* of *landuse* for territories under consideration);
- databases (radioecological, economic, demographic and other monitoring data), including detailed attributive information for each polygon of landuse map;
- spatial analysis of various data from databases, including spatial analysis of radioactive contamination;
- models for various aspects of risk analysis;
- protective measures (countermeasures, CMs) in the long-term period after an accident and estimation of the results of their implementation;
- multi-criteria assessment of CMs effectiveness;
- implementation of radiological protection principles (as well as existing requirements of international and national standards and legal regulations);
- decision-making support on protection of the population and rehabilitation of radioactive contaminated territories both on local and regional/district levels (from separate settlement/field up to group of settlements/farms and region as a whole).

The following *'risk indices'* are considered within decision-making on the basis of *PRANA DSS*:

- surface density contamination of territory with radionuclides (^{137}Cs, ^{90}Sr);
- contamination of agricultural production (plant growing and animal husbandry, including farm and private production);
- external and internal doses to the local population (for different age and occupational groups of each settlement for region under consideration);
- radiological risks caused by irradiation of the population;
- expenses associated with necessity of CMs implementation and rehabilitation procedures along with corresponding criteria of effectiveness.

The interface of the *PRANA DSS* allows using 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), formation of various scenarios for analysis, the estimation of different CMs and subsequent decision making [4, 5]. Presentation of output information comprises all the results on estimations of production contamination, structure of population doses and countermeasure effectiveness as well as integration of estimates from initial polygon (field, settlement) up to the farm or group of farms chosen and district/region as a whole [3-6].

Risk Based Land Management for radioactive contaminated territories is primarily a framework for integration of the following key stages:

- estimation of the main scenarios/variants of rehabilitation (including the choice of sites/territory for remediation along with site-specific CMs and time of their implementation) with consideration of all the main aspects of risk(s) and possible longer term impacts of

particular choices;

- the choice of solution(s): this requires an assessment of overall benefits, costs and environmental side effects, value and circumstances of the land, community and stakeholders views and other issues taking into account values of quantitative and qualitative criteria, principles of radiological protection and existing standards and regulatory documents;
- realisations of the solution(s), taking into account site-specific economic, ecological and other characteristics and requirements.

Contaminated territory management is a set of activities involving decisions about assessment, remediation, land-use restrictions, monitoring, spatial planning, aftercare and other issues. In the context of RBLM, it is a much broader activity than 'choosing a remediation technique'. It includes all the aspects of developing and implementing a sustainable approach taking into account estimates of risks along with other ecological, economic and social factors.

PRANA DSS for practical needs and research is one of the up-to-date tools for risk based land management and for primary evaluation of some aspects within the problem of sustainable appraisal and rehabilitation of radioactive contaminated territories.

The work on development of DSSs for risk based land management and rehabilitation of contaminated territories is a part of R&D carried out within the ISTC project #1224.

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ABSTRACTS OF THE PAPERS

УДК 621.039.526

Physical Parameters of Self-Protection as Guarantees Maintenance of Limiting Power in Perspective Fast S odium Reactor\A.V. Danilytchev, D.G. Elistratov, V.Ju.Stogov, T.M.Burenkova; Editorial board of Journal "Izvestia visshikh uchebnikh zavedeniy, Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) – Obninsk, 2001. – 16 pages, 3 tables, 9 illustrations. – References, 12 titles

The restrictions on limiting power caused by specific distribution of reactivity components of a feedback for the core with basic dimensions of a BN-1600 type reactor are analyzed. The influence of this components on large sodium reactor self-protection to accidents, determining its safety, is considered. The most dangerous accident is indicated. Spatial distribution of Doppler-effect allowing to come nearer to postulated power is investigated for this accident.

УДК 621.039.54

ADS fuel cycle complemented with DUPIC-technology for achieving high fuel burn-up\G.G. Kulikov, A.N. Shmelev; Editorial board of Journal "Izvestia visshikh uchebnikh zavedeniy, Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) – Obninsk, 2001. – 9 pages, 1 table, 3 illustrations. – References, 11 titles

Application of DUPIC-technology for ADS fuel cycle to achieve high fuel burn-up is studed. It is shown that in ADS facility blanket cooled with heavy liquid metal it can be achieved 30 - 40%HM fuel burn-up in slightly sub-critical regime of operation with deterministic safety.

УДК 539.1

Development of the method for calculation of the subcritical reactor target activation\P. Pereslavtsev, D. Sakhrai; Editorial board of Journal "Izvestia visshikh uchebnikh zavedeniy, Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) – Obninsk, 2001. – 9 pages, 2 tables, 5 illustrations. – References, 15 titles

The activation analysis method of the materials irradiated by high energy particles is presented in the paper. Modern computer codes discussed enable to solve an activation problem of arbitrary complicity regardless of the nuclear facility. The analysis of the activity accumulated was performed on the basis of the present-day nuclear data extracted from international libraries and calculated with the help of the computer codes. Results of the codes validations are presented in the paper. As an example, the analysis of the activity, accumulated in the target of the subcritical reactor, is presented.

УДК 502.3

Decision-Making Support on Risk Based Land Management and Rehabilitation of Radioactive Contaminated Territories\ B.I. Yatsalo; Editorial board of Journal "Izvestia visshikh uchebnikh zavedeniy, Yadernaya energetica" (Communications of Higher Schools. Nuclear Power Engineering) – Obninsk, 2001. – 4 pages. – References, 6 titles

The general questions of decision-making support on Risk Based Land Management (RBLM), including key factors and components, range of existing decision support and analytical tools and techniques are considered. The characteristics and possibilities of the applied Decision Support System PRANA as a tool for decision support on RBLM and sustainable rehabilitation of radioactive contaminated territories are briefly described.