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nuclear science and technology

Sustainable restoration and long-term management of contaminated rural, urban and industrial ecosystems (STRATEGY)

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Final report
(summary)

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Introduction

Urban (including industrial), agricultural and semi-natural environments may be contaminated for many years following a nuclear accident. To sustain acceptable living and working conditions, a capability to implement robust and effective restoration strategies is required. Experience after the Chernobyl accident has shown that remediation strategies need to consider a wide range of different issues to ensure the long-term sustainability of radioactively contaminated areas.

Objectives

The STRATEGY project (www.strategy-ec.org.uk) had the overall objective of establishing a holistic decision framework for the selection of optimal remediation strategies for long-term sustainable management of contaminated areas in member states. In optimising restoration strategies, decision makers should aim to achieve a wide range of objectives. Clearly, objectives relevant to radiation protection such as reducing individual and/or collective dose while minimising other health risk factors, meeting legal limitations regarding environmental protection, dose limits and Council food intervention limits, distribution of dose and optimising cost effectiveness are important. In addition, for sustainable use, we need to consider other objectives from a social perspective such as providing public reassurance and maintaining a sense of well-being, minimising social and cultural disruption and environmental damage and maintaining and/or creating economic activity. Decision-making criteria therefore need to be established to balance radiation protection objectives with social, ethical and environmental considerations.

Approaches

Data sheets on countermeasures for mid-/long-term restoration

Countermeasures which can be used in the mid/long term after an accident in rural and urban/industrial areas have been critically evaluated. The approach adopted has been to extend the criteria against which countermeasures are evaluated from simply effectiveness and radiological protection criteria to a more integrated, holistic approach which addresses the wider range of objectives listed above. Specifically, the aspects used to assess available countermeasures were:

(i) Can measures be practically applied (e.g. are the required resources likely to exist or do some environmental characteristics limit the applicability of the measure)?
(ii) Do they incur considerable direct or indirect (side-effect) costs?
(iii) Do they have significant environmental effects?
(iv) Are wastes generated as a consequence of the measure and if so, what are the appropriate methods to dispose of these?
(v) What doses will be received by people implementing the countermeasure?

To achieve this, a critical evaluation was carried out on a range of countermeasures and waste disposal options. A template was devised which provided a means of carrying out a comprehensive and wide-ranging evaluation of different counter-

measures. A review of possible countermeasures which might be used in the mid/long term after an accident was carried out and countermeasures were divided into those considered worth evaluating, those which were rejected as being unlikely to be of use, and those with potential but requiring further development. For those measures fully evaluated, a data sheet based on the template was completed and subsequently peer-reviewed.

Decision-support model

A model-based methodology to identify optimal medium to long-term counter-measure strategies for radioactively contaminated regions has been successfully developed and parameterised for Cs, Sr, Pu and Am. In the model, collective and individual ingestion doses of the region's population are estimated using a spatially variable radionuclide transfer model and a combination of dietary data and information on the geographical sources of foods. External doses are derived from kerma rates for a number of surfaces (e.g. walls, roofs, streets etc.) per unit deposition. These are combined with data describing the distribution of daily activity for the population (e.g. time spent indoors, outdoors etc.).

A restricted range of countermeasures are considered within the model: restrictions on the sale of contaminated foods; shallow ploughing of pastures; deep ploughing of pastures and edible crops; skim and burial ploughing of pastures, edible and silage crops; application of potassium fertilisers and/or lime to pastures and crops; administration of AFCF to animals; clean feeding of animals; washing of roofs, walls and streets; urban topsoil removal; triple digging of gardens; mowing of lawns; pruning of trees in urban areas; and dietary advice. Any combination of these countermeasures can be activated within each grid square and the combined effect on dose simulated. Waste disposal options and environmental (physical and 'legal') restrictions have been included within the implementation of countermeasures as appropriate.

Social issues and stakeholder participation

Work on social issues and stakeholder participation has been an important part of the STRATEGY project, with various end-user interactions as well as specific activities taking place in all work packages, for example engaging stakeholder groups in evaluation of data sheets, use of focus groups within environmental evaluation, and involvement of end-users in case-study exercises.

Theoretical (and desktop) evaluation of social and ethical issues has involved state-of-the-art reviews of the social impact of countermeasure, communication and consultancy practice, and ethical aspects of communication and decision-making in selection of restoration strategies. This work has formed the basis of recommend-ations for good practice, inputs onto countermeasure templates, and decision-making processes.

Embedded in the use of all countermeasures and countermeasure strategies are a set of assumptions about the ways in which the social world works. These assumptions need to be recognised and their validity assessed in the socially and culturally variable range of contexts in which countermeasure strategies may be implemented. In

general, participation in decision-making enables greater compliance and acceptability, leading to more appropriate choices in strategies and greater focus on the dimensions of primary importance to affected groups. As such there has been an emphasis on the inclusion of social and ethical considerations within restoration strategies, for instance ethical conditions for evaluation of communication strategies have been derived from existing conditions for free informed consent in medical ethics.

Socially related objectives on the implementation of countermeasures need to be given due weight and not subsumed by issues connected to dose reduction. Whilst early involvement of the local and wider community of stakeholders within participatory decision-making would be beneficial, mechanisms for doing so need to be identified.

Any decision on countermeasure implementation will have to take into account a large amount of information on the benefits, risks and costs of the restoration strategy and its alternatives. The actual selection of a strategy will require trade-offs and value judgements and almost certainly some lack of agreement within society on what is practical or acceptable. If such a selection is going to be ethically defendable, decision-makers require advice on what criteria are important to consider and why, and also a methodology to ensure a transparent and publicly justifiable procedure for balancing these criteria. As a procedure for ensuring a systematic and transparent consideration of social and ethical aspects of restoration strategies, we introduced the use of a value matrix as practical means by which these can be taken into account in the decision-making process. A template matrix was developed for and the application of the methodology demonstrated with end-users within a case-study exercise. It is important to stress that the matrix is not a substitute for public and/or stakeholder participation. It is a tool that might be used in connection with other possible communication and consultation procedures.

SAMEN-MOSES cluster

The STRATEGY project approaches and output have been discussed within the SAMEN-MOSES cluster (http://www.sckcen.be/samen). This provided a good opportunity to discuss STRATEGY in the context of other EC projects on off-site remediation. Within this co-operation, cluster projects had access to the data sheets prior to their publication. Some SAMEN cluster members provided valuable feedback on the content of some of the data sheets. Stakeholder participation is an important mechanism to explore these additional benefits or disadvantages to the use of countermeasures, and is an essential step in developing a decision framework which avoids problems previously experienced in emergency management. Close liaison with the FARMING stakeholder network facilitated evaluation of countermeasure data sheets for rural ecosystems whilst for other data sheets stakeholders were consulted in small groups or individually. Stakeholder opinion suggested that some countermeasures were as likely to be rejected on socio-ethical grounds as technical and economic grounds. Rejection of specific countermeasures can be expected to show site, context and national differences. A paper summarising stakeholder feedback from across Europe was presented at the WISDOM workshop (http://www.ec-farming.net/wisdom.html).

Main achievements

The project has achieved all of the objectives it set out to meet. The discussion here will focus on the project's three major outputs; other outputs can be found on www.strategy-ec.org.uk, including deliverables on the evaluation of indirect costs and communication strategies and a number of refereed and conference papers.

Data sheets on countermeasures for mid-/long-term restoration

For those measures fully evaluated, a data sheet based on the template was completed. Overall, data sheets were produced for 101 countermeasures, comprising 35 methods for urban/industrial environments, 29 methods for agricultural and semi-natural environments plus 12 associated waste disposal options, 3 methods for forest environments, 7 methods for aquatic environments and 15 methods on social/human/communication issues. A main output was thus a comprehensive, documented, critical evaluation of countermeasures that would be relevant for off-site nuclear emergency management in the mid to long term. The data sheets were peer-reviewed by independent experts and are available as a CD-ROM and on www.strategy-ec.org.uk. Documents on a range of issues including social and legal aspects, dose estimation methodologies and cost effectiveness are hyperlinked to the data sheets.

Population of the data sheets was dependent on relevant information being available. In some cases this required the derivation of novel data, for instance implementation doses to operatives carrying out the measures (completed for the rural data sheets). For some aspects considered, there was a heavy dependence on the particular scenarios and area affected so only general statements could be made.

Decision-support model

The model evaluates the effectiveness of a given combination of countermeasures through a cost function which balances the benefit obtained through the reduction in dose with the cost of implementing countermeasures. The optimal countermeasure strategy is the combination (of individual countermeasures and when and where they are implemented) which gives the lowest possible value of the cost function. Outputs allow an evaluation of resources required and hence present a starting point for discussion of practicability of suggested remediation strategies. Of the 101 countermeasures for which data sheets were generated, 22 are simulated on the basis of their probable use, and only a small number of countermeasure side effects are considered.

In addition to the economic and health implications of a restoration strategy, the model allows the indirect side effects of countermeasure implementation to be assessed, which leads to a more holistic approach to the decision-making process; some additional social dimensions of countermeasure implementation can also be estimated through the model (for example uneven dose distribution). However, whilst there was an initial intention to put numeric values to more social factors to enable their incorporation within the model, it soon became obvious that interaction with affected stakeholders would be required. Therefore, it was decided that further inclusion of social parameters into the model was inappropriate. The model outputs

should be used as inputs into decision-making, rather than a substitute for explicit and inclusive decision-making. Case-study outputs of the model have been used interactively as part of the decision-making process.

Social issues and stakeholder participation

A value matrix is a tool to ensure that all relevant concerns are being taken into consideration and to clarify the ethical basis upon which eventual decisions are made. The matrix approach we proposed takes its starting point in three fundamental principles, namely:

(i) to promote **well-being** and minimise health risks, welfare burdens and other detriments to affected stakeholders
(ii) to respect the **integrity** of affected stakeholders, and
(iii) to recognise the norm of **justice** and aim to treat everybody fairly and ensure an equitable distribution of goods among affected stakeholders.

In practice, a matrix can aid a decision-making group by giving an overall picture of the issue at stake, thereby making the ethical dimension of decision-making more transparent. Different countermeasures can affect different groups in different ways, and the matrix can be used to help identify the relevant information required for decision-making (i.e. the facts, values and stakeholders affected). In this way, a bias towards certain kinds of values may be avoided, and the matrix can be used to address conflicts between values in a systematic way, without necessarily having to invoke full-fledged theories. A further advantage of the matrix is that it is well suited to use within a participatory process with stakeholder representatives of affected parties.

Relevance to radiation protection

The STRATEGY members have agreed that the data sheets should be freely available to any interested parties. Organisations are free to modify them for their own particular needs such as into mother tongues – the data sheets are being translated into German – or regional agricultural or climatic conditions. The decision to provide free access has greatly enhanced interest in the data sheets and increased the probability of them being used in many different countries.

Currently, the rural and waste data sheets are being taken forward by the joint FAO/IAEA division to be adapted to other climate conditions (e.g. tropical) and to update Handbook 363.

The STRATEGY model and countermeasure data sheets CD-ROM were used in a UK off-site emergency exercise (OSCAR 7) recently which helped to identify a number of areas for improvement. In particular, the small-scale nature of the ground deposition (a common characteristic of emergency exercise scenarios) revealed some issues surrounding the time and temporal resolution of the models. While the model could be used to generate useful outputs at small scales, it has been set up with large-scale accidents in mind. This could be addressed in any future work. Feedback on the usefulness of the STRATEGY outputs (and some of the input data) was that these were valuable to the UK Food Standards Agency and to a lesser extent the UK

Environment Agency. This exercise incorporated, for the first time, a stakeholder representation (including local elected officials, farming and business representatives, and the tourist board) as a result of the exercise organiser being a STRATEGY end-user group member. The inclusion of stakeholders was generally taken to have been useful by all participants. The model (and other outputs) would benefit from application in further emergency exercises and discussion and evaluation in the wider emergency response community. The advantages of the approach used need to be compared with other systems and consideration given to incorporating elements of the STRATEGY approach into operational models. The NRPA would like to adopt the model and make it functional on a municipality level in Norway. The goal is to make the model fully operational for use in exercises and possible future accidents of a radiological manner.